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Accuracy Audit of Vehicle Inspection and Maintenance Programs. Volume I

Scott Environmental Technology, Inc, San Bernardino, CA

Prepared for

Environmental Protection Agency, Washington, DC Mobile Source Enforcement Div

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Technical Support Branch
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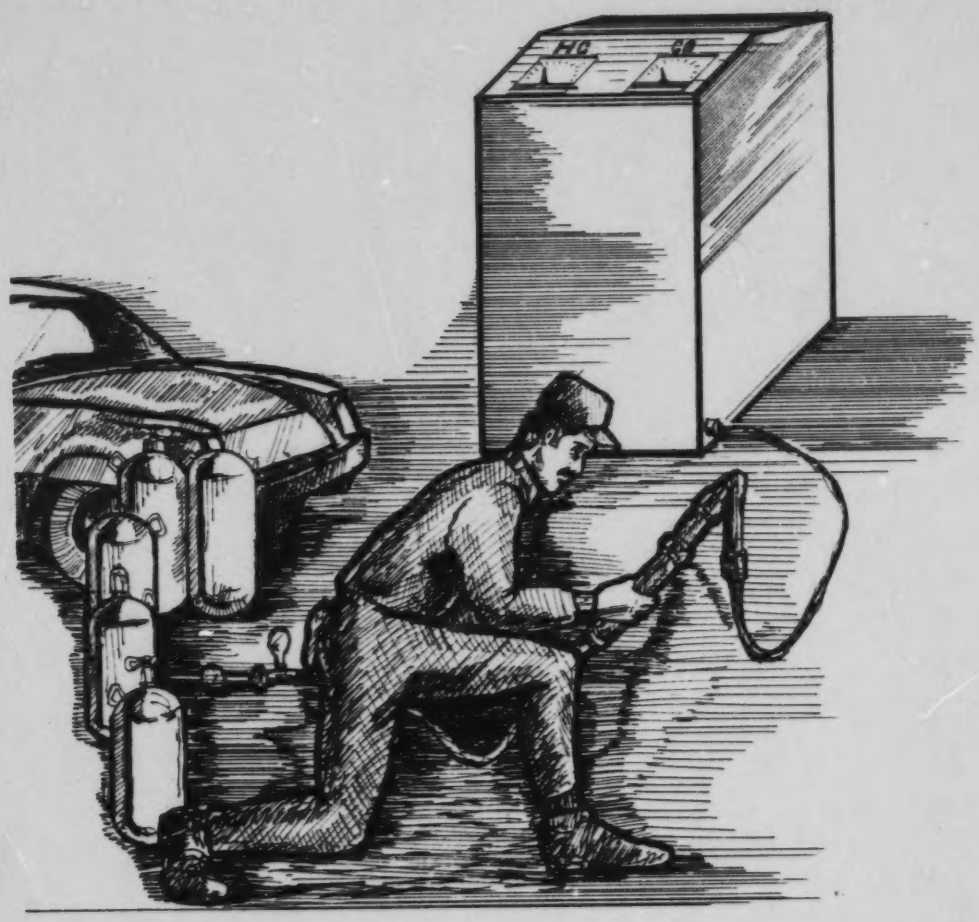

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The contractor conducted an audit of vehicle exhaust emission measuring instrumentation in use at eight I/M areas. Calibration gas standards were introduced into the instruments and responses recorded. Functional checks of the instruments were made and information on instrument reliability and calibration procedures was collected.

Results showed the readings to be within 6 percent,on the average, for both hydrocarbons and carbon monoxide.

Although the basic instrumentation at each station was very similar, the degree of computer automation and instrument calibration procedures varied widely from program to program.

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FINAL REPORT

Accuracy Audit of Vehicle Inspection and Maintenance Programs

Volume I

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EPA Contract No.: 68-01-3946

Prepared for:

Environmental Protection Agency
Mobil Source Enforcement Division
Technical Support Branch
401 "M" Street, S.W.
Washington, D.C. 20460

March 1979

by

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REPORT AVAILABILITY

Copies of this report are available for a limited time through the Mobile Source Enforcement Division, (EN-340), 401 M St., Washington, D.C., or at a nominal cost from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161 (703-557-4650)

This is Volume I of a two volume report submitted by the contractor. Volume II is a compilation of the raw data sheets and was not published.

DISCLAIMER

This report has been reviewed by the Technical Support Branch, Mobile Source Enforcement Division, U.S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

SET #2587-01-0179

ABSTRACT

Scott Environmental Technology, Inc. conducted an audit for the Environmental Protection Agency of vehicle exhaust emission measuring instrumentation currently in use at vehicle inspection and maintenance stations. Calibration gas standards were introduced into the instruments and responses recorded. Functional checks of the instruments were also made and information on instrument reliability and calibration procedures was collected.

Results generally showed the instruments to be in good condition with readings within 6 percent of the standard gases for both hydrocarbons and carbon monoxide. Graphical and statistical analysis of the results showed significant variations in the measurements at only a few locations.

Although the basic instrumentation at each station was very similar, the degree of computer automation and instrument calibration procedures varied widely from program to program.

TABLE OF CONTENTS

		Page Number
ABSTRACT		
1.0	INTRODUCTION	1-1
2.0	SUMMARY OF RESULTS	2-1
3.0	SUMMARY OF INSPECTION MAINTENANCE PROGRAMS	3-1
4.0	AUDIT PROCEDURE	4-1
4.1	GAS PREPARATION	4-1
4.2	FIELD EVALUATION OF EMISSION INSTRUMENTATION	4-3
5.0	RESULTS OF AUDIT	5-1
6.0	DATA ANALYSIS OF RESULTS	6-1

APPENDIX A - SUMMARY OF ANALYSIS OF GAS BLENDS BY SCOTT ENVIRONMENTAL TECHNOLOGY, INC.

- ANALYSIS OF LOW PRESSURE CYLINDERS TRANSFILLED FROM MASTER CYLINDERS

APPENDIX B - SUMMARY OF AUDIT RESULTS INCLUDING DIFFERENCES BETWEEN INSTRUMENT READINGS AND STANDARD GASES

1.0 INTRODUCTION

An audit of inspection and maintenance (I/M) programs was conducted by Scott Environmental Technology, Inc. for the United States Environmental Protection Agency under Contract No. 68-01-3946. The primary objective of the audit was to determine the ability of emission analyzers currently in use at state and city vehicle inspection and maintenance stations to accurately measure the concentrations of hydrocarbons and carbon monoxide in vehicle exhaust. Additional objectives included determining the general condition of the instruments, instrument maintenance histories, and calibration procedures at each program.

Inspection and maintenance programs involve periodic vehicle inspection of exhaust emissions. A number of I/M programs have been implemented across the country by state and local governments. Selected for inclusion in the audit were programs from the following eight locations: Chicago, Illinois; Cincinnati, Ohio; Denver, Colorado; New Jersey; New York State; Phoenix/Tucson, Arizona; Portland, Oregon; and Riverside, California.

In order to determine the accuracy of the emission measurements, Scott conducted field evaluations of the instrumentation used by each program.

Hydrocarbons and carbon monoxide gas standards of known concentrations were introduced into the instruments by Scott personnel and instrument responses recorded. The results are presented in tabular and graphical form with a statistical analysis of the data and background information on the programs.

Volume I of this report contains descriptions of the inspection and maintenance programs and the audit procedure, results of the audit, and the statistical and graphical analysis of results. Volume II contains the data forms completed by Scott personnel during the field evaluation of the I/M stations.

2.0 SUMMARY OF RESULTS

In the eight programs audited, a total of 24 I/M stations and 58 instruments were evaluated. Generally, the instruments were found to be in very good operating condition, although a few were out of service for minor repairs. The instruments require only routine maintenance, with attention given to leaks or plugging in the sampling system. Calibration procedures varied from program to program. Calibrations with precision gases varied from once per day to once per month. Frequency of electronic calibration was also quite variable. Some programs were highly automated, using computers to operate the instrumentation, while others operated the instruments manually.

The difference between the analyzer readings and the known standard gases was about 6% for both hydrocarbons and carbon monoxide. Statistical analysis of the results showed some significant differences in the mean values of the hydrocarbon measurements between the programs and the individual sites, especially at higher concentrations. The analysis of the carbon monoxide results showed some differences between the sites in analyzing the standard gases, but no differences between programs.* There was also no significant difference between the makes of analyzers in analyzing either hydrocarbons or carbon monoxide.

* - Excluding Portland, see text.

3.0 SUMMARY OF INSPECTION MAINTENANCE PROGRAMS

The I/M programs included in the audit vary widely in size and program objectives. Both voluntary and mandatory programs were included. The scope of the programs varies from state-wide inspections to only one station programs. All of the programs test for emissions of hydrocarbons and carbon monoxide, with several also testing for nitrogen oxides. With the exception of Denver, all of the programs use similar instrumentation based on infrared absorption detection principles to measure hydrocarbons and carbon monoxide. Test modes also vary, with some tests at only idle and others at cruising conditions using dynamometers to simulate road loads. Although the basic instrumentation used by the various programs is very similar, there are wide variations in the degree of automation of the instrumentation. The more complex systems use a computer to fully control the instrumentation, except for inserting the sampling probe into the tailpipe and operating the vehicle being tested. In some programs, the computer automatically draws exhaust gas samples, purges the sampling lines, checks instrument zero and span, determines vehicle compliance, and prints test results.

The following are the I/M programs included in the audit:

1. Chicago Department of Environmental Control, Chicago, Illinois
2. Cincinnati Division of Air Pollution Control, Cincinnati, Ohio
3. Colorado Department of Health Denver, Colorado
4. New Jersey Department of Environmental Protection, State of New Jersey
5. New York State Department of Environmental Conservation, Latham, New York
6. Arizona Bureau of Vehicular Emissions Inspection Phoenix and Tucson, Arizona

7. Oregon Department of Environmental Quality
   Portland, Oregon
8. California Bureau of Automotive Repair
   Riverside, California

Details of these programs are summarized in Table 3.1.

TABLE 3.1

SUMMARY OF INSPECTION MAINTENANCE PROGRAMS

PROGRAM LOCATION	MANDATORY OR VOLUNTARY[1]	DATE PROGRAM BEGAN	EXHAUST GASES MEASURED	NUMBER OF I/M STATIONS[2]	TOTAL NUMBER OF TEST LANES	TOTAL NUMBER OF INSTRUMENTS	TEST MODES	APPROX. VOLUME VEHICLES PER YEAR, THOUSANDS
Chicago, Ill.	V	6-01-73	HC, CO, CO_2	5P 9M	28	28	Idle 2500 rpm	110
Cincinnati, Ohio	M	1-01-75	HC, CO	2P	7	9	Idle	200
Denver, Colorado	V	3-75	HC, CO, NO_x	1P 1M	2	2	Idle, High cruise, low cruise	Not Avail.
New Jersey	M	1972	HC, CO	38P	68	125	Idle	4000
N.Y. State Lab[3] Albany, New York	V	1972	HC, CO	1P 1M	2	2	Idle, High Cruise	1
Phoenix/Tucson, Ar.[4]	M	1-01-76	HC, CO	12P	34	34	High Cruise, Low Cruise, Idle	1000
Portland, Oregon	M	1-01-74	HC,CO, CO_2	6P 3M	29	29	Idle 2500 rpm	300
Riverside, Ca.[5]	V	9-02-75	HC,CO CO_2	2P	6	6	High Cruise, Low Cruise, Idle	12

1. M- Mandatory, V-Voluntary
2. P-Permanent, M-Mobile
3. New York conducted voluntary program from 1972-1976.
4. Arizona State Laboratory also included in audit.
5. Program has ended, to be replaced with mandatory program

4.0 AUDIT PROCEDURE

To check the accuracy of the instrumentation used by the I/M programs, several standard gas blends containing different levels of hydrocarbons (propane) and carbon monoxide were prepared and subsequently introduced into the instruments through their sampling probes. The instrument responses for each of the gas blends were then recorded. The audit procedure also included zeroing and spanning the instruments before and after measuring the standard gases and a leak check of the instrument sampling system. Background information on the programs also was obtained.

Site Selection - I/M stations selected to be audited included all of the stations of the Cincinnati, Denver, New York and Riverside programs. Stations from the remaining programs were selected at random using computer-generated random numbers. The following numbers of stations were selected from each program: Four from Chicago and Portland; 3 from Phoenix/Tucson plus the Arizona State Laboratory; and 5 from New Jersey. Table 4.1 shows the addresses of all of the I/M stations, the stations selected for the audit, and the dates of the field visits. A total number of 24 stations with 58 instruments were audited. A list of persons contacted in each program and a sample of the letter sent to each program are included in Figure 4.1.

4.1 GAS PREPARATION

The standard gases used in the audit were prepared by Scott's Specialty Gas Division. Five tri-blend mixtures of varying concentrations of propane, carbon monoxide, and nitrogen were gravimetrically blended into high pressure cylinders. Gravimetrically prepared gas mixtures are prepared by weighing the gas components on a high load, high sensitivity analytical balance. All weights are traceable to the National Bureau of Standards.

Each of these five blends was then transferred into 20 low pressure 8 cubic foot cylinders. Gas concentrations in each of the cylinders were verified by gas chromotography against Scott's primary standards. This gas blending procedure was used in order to provide identical gas blends in each of the 20 cylinders and gas analysis of the highest accuracy.

One set of each of the five blends was also analyzed by the U.S. Environmental Protection Agency Motor Vehicle Emission Test Laboratory in Ann Arbor, Michigan. Another set of gases was analyzed by EG&G Automotive Research, Inc., in Alexandria, Virginia. After the audit of each program was

TABLE 4.1

ADDRESSES OF INSPECTION/MAINTENANCE STATIONS
SHOWING STATIONS SELECTED TO BE AUDITED

Chicago:

*1. 4046 Washington Street
2. 4633 S. Marshfield
*3. 31st Street & Lakeshore Drive
*4. 5401 N. Elston
*5. 7150 W. Medill

Cincinnati:

*1. Central Parkway & Bates
*2. Mills Avenue & Walter Avenue, Norwood

Denver:

*1. 1549 Chester St., Aurora
*2. Mobile Laboratory

New York:

*1. Motor Vehicle Emissions Test Program, 8 Hemlock Street, Latham, New York

Portland:

1. 625 S.W. Oak St., Hillsboro
*2. 13900 S.W. Pacific Hwy, Tigard
3. 3136 Harrison St., Milwaukie
*4. 4621 N.W. St., Helens Road
*5. 8920 S.E. Powell Blvd.
*6. 18345 S.E. Stark Street
*7. 185th Street & Sunset Highway
*8. Lloyd Center-NE 15th & Multanomah

Phoenix/Tucson:

1. 4501 W. Van Buren, Phoenix
2. 8802 N. Black Canyon, Phoenix
3. 12620 N. Cave Creek Rd., Phoenix
4. 1700 N. Hayden Rd., Tempe
*5. 1830 W. Broadway, Mesa
*6. 2450 S. 7th St., Phoenix
7. 579 Whipple St., Wickenburg
8. 1311 E. Highway 80, Buckeye
9. 1402 E. Benson Hwy., Tucson
10. 755 W. Grant Rd., Tucson
*11. 8125 E. 22nd St., Tucson
12. 2020 N. Ajo-Gila Bend Hwy., Ajo
*13. State Vehicular Emissions Eng. Lab. 600 N. 40th St., Phoenix

Riverside:

**1. 1970 University Drive
*2. 3195 Motorcircle Drive

New Jersey:

1. 1010 Comstock St., Asbury Park
2. Drive-In Theatre, Rte 30, Atco
3. Wabash & Maryland Aves, Atlantic City
4. 83 Cornwells Drive, Bridgeton
5. Creek Rd, Delanco, Burlington
6. 617 Hampton Rd, Merchantville, Camden
*7. US Hwy 9 & Shellbay Ave., Cape May C.
8. 725 Egg Harbor Rd., Deptford
9. Highway 36, Eatontown
10. Junction, Rte 12 & 31, Flemington
11. Rte 9 (1 mi. south), Freehold
12. Drive-In Theatre, Bergen Pike, Hackensack
13. 177 Roosevelt Ave., Jersey City
14. 33 Kilmer Rd, Edison, Kilmer
15. Drive-In Theatre, Rte 10, Livingston
16. Mill St. off Garibaldi Avenue, Lodi
17. 220 Recovery Road, Manahawkin
18. 1406 Wheaton Ave., Millvile
19. 16 Label Street, Montclair
*20. Ridgedale Ave & Washington Place, Morristown
21. Madison Avenue & Rte 38, Mount Holly
22. 28 Frelinghuysen Ave., Neward
23. 90 Moran Street, Newton
24. Drive-In Theatre, Rte 1, N. Brunswick
25. W. 20 Century Road, Paramus
26. 1600 S. Second St., Plainfield
27. Woodbridge Ave., adjoining Prison, Rahway
*28. 156 Chestnut Street, Ridgewood
29. Rte 45 (1 mi north of Salem), Salem
30. County Ave., & Secaucus Rd., Secaucus
*31. 61 Central Avenue, Somerville
*32. 935 Lakewood Rd., at James Street, Tom's River
33. Rte 1, Brunswick Pike, Trenton
34. Drive-In Theatre, Rte 22, Union
35. Rte 31, Washington
36. 481 Rte 46 (½ mi east of 23).Wayne
37. Windsor Avenue off South Ave., Westfield
38. Rte 10-Mt. Pleasant Ave., Whippany

* Stations selected to be audited.
** Station closed at the time of audit.

TABLE 4.1 CONTINUED

DATES OF FIELD VISITS

Program	Station	Date of Field Visit
Chicago, Ill	31st and Lakeshore	2-28-78
	Elston	3-1-78
	Medill	3-1-78
	Washington	2-28-78
Cincinnati, Ohio	Central Parkway	3-28-78
	Norwood	3-28-78
Denver, Colo.	Aurora	1-10-78
New Jersey	Somerville	2-1-78
	Morristown	2-2-78
	Ridgewood	2-2-78
	Tom's River	2-9-78
	Cape May	2-10-78
New York State	State Laboratory	2-23-78
Arizona	State Laboratory	1-31-78
	Phoenix	1-31-78
	Mesa	2-1-78
	Tucson	2-1-78
Portland, Oregon	Tigard	2-15-78
	Powell	2-14-78
	St. Helens	2-15-78
	Stark	2-14-78
	185th & Sunset	2-15-78
	Lloyd Center	2-15-78
Riverside, Calif.	Motor Circle	1-5-78

FIGURE 4.1

INSPECTION/MAINTENANCE PROGRAM PERSONNEL CONTACTED

Mr. Joe Seliber
City of Chicago
Department of Environmental Control
320 North Clark Street, Room 402
Chicago, Illinois 60610

Mr. Don Sorrels
Chief, Mobile Sources Section
Air Pollution Control Division
Colorado Department of Health
4210 East 11th Avenue
Denver, Colorado 80220

Mr. Walter J. Pienta
Mobile Source Section
New York State Department of
Environmental Conservation
50 Wolf Road
Albany, New York 12233

Mr. Marion F. Smith
Senior Engineer
City of Cincinnati
Division of Air Pollution Control
2400 Beekman Street
Cincinnati, Ohio 45214

Mr. John Elston, Supervisor
Mobile Source Control
Bureau of Air Pollution Control
New Jersey State Department of Environmental
Protection
P.O. Box 2807
Trenton, New Jersey 08625

Mr. Fred Iacobelli
State of Arizona
Bureau of Vehicular Emissions Inspection
1740 West Adams Street
Phoenix, Arizona 85007

Mr. William P. Jasper
Department of Environmental Quality
Vehicle Inspection Division
1234 S.W. Morrison Street
Portland, Oregon 97205

Mr. John H. Dolan
Bureau of Automotive Repair
3116 Bradshaw Road
Sacramento, California 95827

Scott Environmental Technology Inc.
2600 CAJON BLVD., SAN BERNARDINO, CALIFORNIA 92411 (714) 887-2571

Scott Environmental Technology, Inc. is conducting an audit of vehicle inspection and maintenance stations across the country under a contract with the Technical Support Branch of the U.S. Environmental Protection Agency, Washington, D.C.. The stations to be included in the audit are from programs in Arizona, California, Chicago, Il., Cincinnati, Oh., Colorado, New Jersey, New York and Oregon. I am writing to ask your approval to include your program in the audit. Your support and assistance will greatly contribute to the success of the audit.

The primary objective of the audit is to determine the ability of emission analyzers currently in use at inspection/maintenace stations to accurately measure hydrocarbon and carbon monoxide levels in vehicle exhausts. The audit will also provide information on instrument reliability and calibration procedures.

The audit will consist of a visit by a Scott Instrument Technician to each station. Five different gases of unknown concentration blended by Scott's Specialty Gas Department will be introduced into each of the station's instrumentation systems, and the responses for hydrocarbon and carbon monoxide will be recorded. The unknown gases will be analyzed by Scott's Chemical Laboratory and the EPA. The Scott technician will also gather additional information including instrument maintenance records and calibration procedures. Upon completion of the audit of each program, results of the audit will be released to appropriate program officials. The results will then be analyzed statistically to determine any significant differences between types of analyzers, inspection/maintenance programs, or individual sites.

FIGURE 4.1, Page 3

With your approval, we plan to include stations from your inspection and maintenance program. These stations will be chosen randomly. Scott's technicians are scheduled to visit each station in December and January. We will inform you of the exact dates when the schedule is firm.

You may assist us in the audit at this time by providing information about the inspection and maintenance stations in your program. On the following page, Attachment #1, we have listed the number and location of your stations and the make and model number of the instruments we believe are currently in use. We would appreciate your confirming the number and addresses of the stations, and indicating the number, make and model numbers of instruments in use at each station. We are also interested in the pressure and flow rate of the exhaust gas samples through the instrument system. It would be very helpful if you could provide us with a copy of the instruction manual for the instruments.

In order to coordinate the visits of our technicians to your inspection stations, please include the names of the responsible persons we should contact at each station.

The Project Officer for the EPA is Mr. James Caldwell, 202/755-9396.

If you have any questions about the audit, I would be happy to discuss the program further with you. I look forward to hearing from you.

Sincerely,

James L. Reese
Program Manager

JLRs

Attachment: 1

completed, the gases used in the audit were reanalyzed by Scott. The concentrations of the original gas blends by Scott, along with the analysis by the EPA and EG&G are shown in Table 4.2. The results of the reanalysis of the blends by Scott are included in Appendix A.

4.2 FIELD EVALUATION OF EMISSION INSTRUMENTATION

The field evaluation of the I/M instrumentation consisted of Scott personnel visiting each station to introduce the standard gases into the instruments. This procedure insured that the audit was conducted in the correct manner and also allowed Scott to note the general condition of the instruments and obtain information on instrument calibration and maintenance at each station. To maintain the integrity of the standard gases, the gas cylinders were shipped to the cities of the I/M programs and held for pickup at the shipping company terminals by Scott personnel. The cylinders were then hand carried to each I/M station by Scott personnel. The concentrations of the standard gases were not revealed to any I/M personnel at the stations. I/M personnel were aware of the dates of the audits, although they were not aware of the specific sites selected when not all sites were audited. Personnel at the program headquarters in New Jersey and Chicago were informed of the concentrations, although station personnel were not.

Before the I/M instruments analyzed the standard gas, a leak check was performed on the instrument sampling system. The instruments were also checked for correct zero and span before and after the audit, with adjustments made, if necessary. The standard gases were introduced in a random order into each instrument using a flow control device to insure that the instrument sampling systems were not over or under-pressurized. The flow control device included a pressure regulator and balloon. The precise gas flow rate required by the instrument was obtained by increasing the gas flow to the instrument until the balloon inflated slightly. Figure 4.2 shows the gas cylinder-to-instrument sampling probe connection. The gases were introduced at the instrument sampling probe in order to evaluate the accuracy of the entire instrumentation system. Instrument response to each gas blend was then recorded.

The cylinders were transported by automobile to the stations of the New Jersey and Riverside programs. For the other programs, it was necessary to ship the cylinders by truck to the city of the program. The cylinders were then held at the freight company terminal for subsequent pickup by Scott personnel. Scott personnel then hand-carried the cylinders to each station to perform the audit.

TABLE 4.2

ANALYSIS OF STANDARD GASES

HC - Hydrocarbons as Propane in parts per million.

CO - Carbon Monoxide in percent.

	Scott Gravimetric Blend[1]		EPA, Ann Arbor Analysis[2]		E. G. & G. Analysis[3]		E. G. & G. Bench[4]
Blend	HC	CO	HC	CO	HC	CO	HC
1	0	0	0	0	0	0	0
2	388	.903	392	.905	382	.875	419
3	821	2.13	826	2.15	801	2.08	876
4	1960	4.84	1990	4.88	1899	4.58	---
5	3840	9.56	3902	9.68	3613	9.25	---

Notes:
1. Gases blended gravimetrically using weights traceable to the National Bureau of Standards.
2. E.P.A., Ann Arbor analysis of gas blends "A" by Motor Vehicle Emission Test Laboratory.
3. EG&G analysis of gas blends "B" by Sun Electric automobile testing instrumentation.
4. EG&G bench instrumentation.

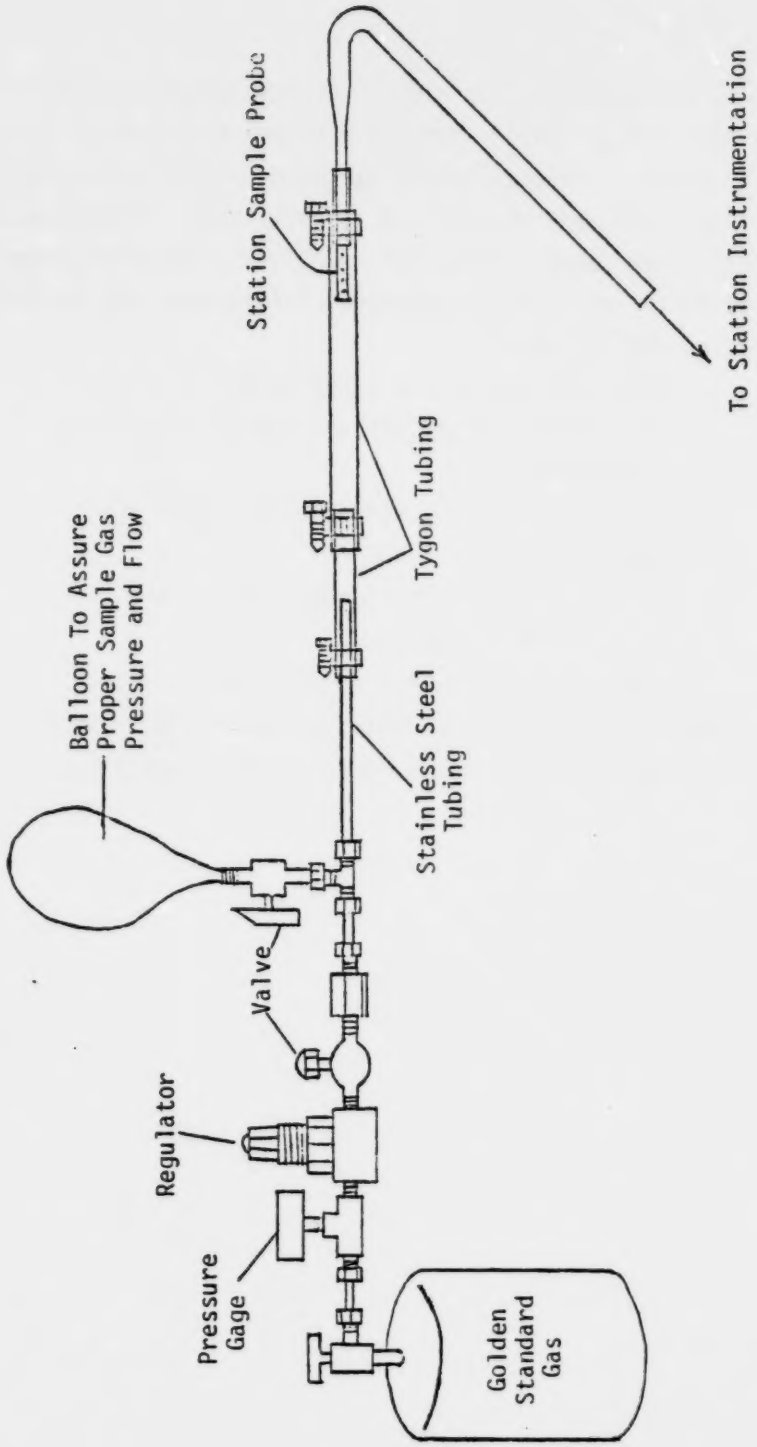


FIGURE 4.2

GAS HANDLING SYSTEM

At a few of the stations, the highest propane concentration of standard gas (3840 ppm propane) read off scale of the instrument. This result was caused by either a propane/hexane factor of higher than 0.52 for the instrument, or the instrument reading was slightly high. Future audits should use a somewhat lower concentration for the highest level of propane.

During the field evaluation, background information was obtained on each station, including the following:

- Brief history of the I/M Program.
- Description of station and vehicle inspection procedures.
- Make and model of each emission inspection instrument.
- Description of exhaust sampling system.
- Calibration procedures.
- Summary of instrument maintenance records.

The field data form showing the specific background information collected and the instrument test procedure is shown in Figure 4.3.

FIGURE 4.3

Inspection/Maintenance Station Audit

FIELD DATA FORM

Date of Visit:_____ Scott Personnel:_____

I/M Station Background Information:

City of I/M Station:_____

Agency Responsible for Station:_____

Contractor(s) and_____

Services Performed:_____

Address of Station:_____

Person(s) Contacted:_____

Position:_____

Phone Number:_____

Total Number of Stations in this Agency's I/M Program:_____

Type of Program: Voluntary _____ Mandatory _____

Description of Test Program: (Types of vehicles tested, frequency, brief history of program)

_____

_____

_____

_____

_____

_____

Number of Testing Lanes at this Location:_____

Number of Testing Lanes at Other Locations:_____

Brief Description of Test Station:_____

_____

_____

FIGURE 4.3, Page 2

Vehicle Inspection Procedure (types of inspections, engine operating modes):

_____

_____

_____

_____

_____

_____

_____

_____

Estimated Number of Vehicles Tested:_____Per_____

Station Operating Hours:_____

Length of Time Station has been in Operation:_____

Emissions Instrumentation Background Information:

Make of Instruments:_____ _____ _____ _____ _____

Model Nos.:_____ _____ _____ _____ _____

Serial Nos.:_____ _____ _____ _____ _____

Instrument Range(s):_____ _____ _____ _____ _____

Propane/Hexane Factor:_____ _____ _____ _____ _____

Station Instrument Calibration Procedure, Including Frequency and Precision:
(Attach copy of standard procedure, if available)

_____

_____

_____

_____

_____

_____

_____

_____

FIGURE 4.3, Page 3

Inspect Maintenance Records of Instruments, if available.

Summarize Instrument History (Note malfunctions and repairs) for past 12 months:

_____

_____

_____

_____

_____

_____

_____

Estimated Percentage of Time Instruments Operational: _____

Levels and Precision of Calibration Gas Maintained by Station:

HC: _____ CO: _____ Other: _____

Description of Vehicle Exhaust Sampling System (include diagram of system and sampling probe):

_____

_____

_____

Sampling Pressure and Flow Rate: _____

Recommended by Manufacturer: _____

Utilized by Station: _____

FIGURE 4.3, Page 4

Complete pages 4 & 5 for each instrument at inspection station: Lane #_____ Serial #_____

Instrument Test Procedure

1. Note General State of Repair of Instrument and Any Visible Impairments:_____

_____

_____

2. Sample Train Leak Check:

   a. Connect Flow Meter to Analyzer Outlet:_____

   b. Plug Inlet to Analyzer Train:_____

   c. Turn on Analyzer:_____

   d. Record Magnitude of Flow, if any:_____

3. Following Standard Procedure at Site:

   Record Zero HC:_____ CO:_____

   Record Span HC:_____ CO:_____

   Span Gas HC:_____ CO:_____

   Adjust Zero, if necessary.

   Adjust Span, if necessary.

4. Cylinder Letter of Scott "Gold Standard" Gas:_____

   Using the balloon, enter each blend of "Gold Standard" gas at the same flow rate and pressure as used for test vehicles.

   Use cylinders in random order.

   Allow gas flow for a minimum of 20 and a maximum of 60 seconds.

Record Instrument Response.

		HC (ppm as_____)		CO (%)			
Order Tested	Gold Standard	Reading	Instr. Range	Reading	Instr. Range	Cylinder Start	Pressure Finish
_____	Blend 1	_____	_____	_____	_____	_____	_____
_____	Blend 2	_____	_____	_____	_____	_____	_____
_____	Blend 3	_____	_____	_____	_____	_____	_____
_____	Blend 4	_____	_____	_____	_____	_____	_____
_____	Blend 5	_____	_____	_____	_____	_____	_____

FIGURE 4.3, Page 5

5. Respan Instrument:_____

   Rezero Instrument:_____

   If significant drift, repeat Step 4.

Note possible causes of instrument malfunction such as: sampling handling system, I/M station calibration procedure, readily identifiable instrument malfunction:

_____

_____

_____

_____

5.0 RESULTS OF AUDIT

Twenty-four I/M stations were audited in the eight programs. At these stations, a total of 58 instruments were evaluated. Table 5.1 shows a breakdown of the numbers of instruments and stations tested in each program and the make and model of instruments in use.

TABLE 5.1
SUMMARY OF INSTRUMENTS AUDITED

Program	No. of Stations Audited	No. of Instruments Audited	Make and Model of Instrument
Chicago	4	7	Sun Electric EPA-75
Cincinnati	2	7	Sun Electric EET-910I
Denver	1	1	Beckman 400 (HC) Beckman 864 (CO)
New Jersey	5	13	Sun Electric NJ-910
New York State	1	2	Sun Electric EPA-75M
Phoenix/Tucson	3	9	Autosense (Custom)
Arizona State Laboratory	1	1	Beckman 864 (HC & CO)
Portland	6	16	Sun Electric OEA-75
Riverside	1	2	Horiba Mexa 300A
TOTAL	24	58	

The audit results for hydrocarbons are shown in Table 5.2 and the carbon monoxide results are shown in Table 5.3. Although the instruments read in parts per million (ppm) as hexane (C_6) for hydrocarbons, the results are presented in ppm as propane (C_3). Since the standard gas was propane, there would be a different value for the standard gas for each instrument if results were reported as hexane. This propane/hexane factor is used to convert the individual instrument readings from hexane to propane. For reference, the hydrocarbon results are also presented as hexane in Appendix B. Appendix B also shows the carbon monoxide results and the differences between the instrument readings and the standard gases.

TABLE 5.2

HYDROCARBON RESULTS (ppm AS PROPANE)

BLEND NO.: 1 SCOTT ANALYSIS: 0

STATION:	31ST & LAKESHORE			N. ELSTON AV		W MEDILL AVE		WASHINGTON	
LANE NO:		B		A	B	1A	2B	A	B
CHICAGO, ILLINOIS		0		78	-3	0	-4	39	0

STATION:	CENTRAL PARKWAY						NORWOOD
LANE NO:	1	2	3	4	5	6	2
CINCINNATI, OHIO	0	0	18	0	0	0	0

STATION:	AURORA
LANE NO:	1
DENVER, COLORADO	16

STATION:	SOMERVILLE			MORRISTOWN			RIDGEWOOD		TOM'S RIVER			CAPE MAY	
LANE NO:	100	073	091	045	124	051	055	063	101	102	103	107	106
NEW JERSEY	0	55	0	0	0	0	0	0	0	58	0	0	0

STATION:	STATE LAB	Mobile
LANE NO:	1	Van
NEW YORK STATE	0	37

STATION:	LAB	PHOENIX			MESA			TUCSON		
LANE NO:	---	1	2	3	1	2	3	1	2	3
PHOENIX/TUCSON, AR	2	0	0	0	0	0	0	0	0	0

STATION:	TIGARD			POWELL BOULEVARD				ST. HELENS		STARK			185 & SUNSET		LLOYD CNTR	
LANE NO:	U	L	T	1-H	1-S	2-Z	2-I	A	O	AA	M	N	V	W	D	C
PORTLAND, OREGON	55	10	12	9	74	37	38	9	9	9	19	28	0	28	0	0

STATION:	MOTOR CIRCLE	
LANE NO:	1	2
RIVERSIDE, CALIF.	0	2

SET #2587-01-0179

TABLE 5.2 (Page 2)

HYDROCARBON RESULTS (ppm AS PROPANE)

BLEND NO.: 2 SCOTT ANALYSIS: 388

STATION:	31ST & LAKESHORE			N. ELSTON AV		W MEDILL AVE		WASHINGTON								
LANE NO:		B		A	B	1A	2B	A	B							
CHICAGO, ILLINOIS		388		502	474	422	416	380	411							
STATION:	CENTRAL PARKWAY						NORWOOD									
LANE NO:	1	2	3	4	5	6	2									
CINCINNATI, OHIO	570	529	370	366	386	398	389									
STATION:	AURORA															
LANE NO:	1															
DENVER, COLORADO	438															
STATION:	SOMERVILLE			MORRISTOWN			RIDGEWOOD		TOM'S RIVER			CAPE MAY				
LANE NO:	100	073	091	045	124	051	055	063	101	102	103	107	106			
NEW JERSEY	385	473	365	385	340	415	385	400	308	346	377	404	481			
STATION:	STATE LAB															
LANE NO:	1	Mobile Van														
NEW YORK STATE	415	407														
STATION:	LAB	PHOENIX			MESA			TUCSON								
LANE NO:	---	1	2	3	1	2	3	1	2	3						
PHOENIX/TUCSON, AI	388	373	368	364	371	367	372	365	365	381						
STATION:	TIGARD			POWELL BOULEVARD				ST. HELENS		STARK			185 & SUNSET		LLOYD CNTR	
LANE NO:	U	L	T	1-H	1-S	2-Z	2-I	A	O	AA	M	N	V	W	D	C
PORTLAND, OREGON	441	390	407	358	438	374	414	393	402	346	392	377	400	391	374	396
STATION:	MOTOR CIRCLE															
LANE NO:	1	2														
RIVERSIDE, CALIF.	400	408														

TABLE 5.2 (Page 3)

HYDROCARBON RESULTS (ppm AS PROPANE)

BLEND NO.: 3 SCOTT ANALYSIS: 821

STATION:	31ST & LAKESHORE			N. ELSTON AV		W MEDILL AVE		WASHINGTON	
LANE NO:		B		A	B	1A	2B	A	B
CHICAGO, ILLINOIS		620		929	1006	895	894	761	875

STATION:	CENTRAL PARKWAY						NORWOOD
LANE NO:	1	2	3	4	5	6	2
CINCINNATI, OHIO	808	769	776	772	809	814	833

STATION:	AURORA
LANE NO:	1
DENVER, COLORADO	917

STATION:	SOMERVILLE			MORRISTOWN			RIDGEWOOD		TOM'S RIVER			CAPE MAY	
LANE NO:	100	073	091	045	124	051	055	063	101	102	103	107	106
NEW JERSEY	769	655	808	769	755	811	808	800	712	808	943	827	885

STATION:	STATE LAB	
LANE NO:	1	Mobile Van
NEW YORK STATE	830	850

STATION:	LAB	PHOENIX			MESA			TUCSON		
LANE NO:	---	1	2	3	1	2	3	1	2	3
PHOENIX/TUCSON, AI	800	763	769	762	760	787	778	779	796	796

STATION:	TIGARD			POWELL BOULEVARD				ST. HELENS		STARK			185 & SUNSET		LLOYD CNTR	
LANE NO:	U	L	T	1-H	1-S	2-Z	2-I	A	O	AA	M	N	V	W	D	C
PORTLAND, OREGON	864	848	833	772	847	748	829	822	832	749	813	763	838	791	776	792

STATION:	MOTOR CIRCLE	
LANE NO:	1	2
RIVERSIDE, CALIF.	825	831

SET #2587-01-0179

TABLE 5.2 (Page 4)

HYDROCARBON RESULTS (ppm AS PROPANE)

BLEND NO.: 4 SCOTT ANALYSIS: 1960

STATION:	31ST & LAKESHORE			N. ELSTON AV		W MEDILL AVE		WASHINGTON	
LANE NO:		B		A	B	1A	2B	A	B
CHICAGO, ILLINOIS		1983		2106	2374	2101	2104	1761	2057

STATION:	CENTRAL PARKWAY						NORWOOD
LANE NO:	1	2	3	4	5	6	2
CINCINNATI, OHIO	1901	1731	1885	1890	1884	1941	1898

STATION:	AURORA
LANE NO:	1
DENVER, COLORADO	2458

STATION:	SOMERVILLE			MORRISTOWN			RIDGEWOOD		TOM'S RIVER			CAPE MAY	
LANE NO:	100	073	091	045	124	051	055	063	101	102	103	107	106
NEW JERSEY	2000	2018	1904	2038	1887	2000	1981	2080	1885	1885	2491	2163	2288

STATION:	STATE LAB	Mobile Van
LANE NO:	1	
NEW YORK STATE	2038	1959

STATION:	LAB	PHOENIX			MESA			TUCSON		
LANE NO:	---	1	2	3	1	2	3	1	2	3
PHOENIX/TUCSON, AR	1933	1881	1873	1871	1890	1906	1878	1907	1891	1891

STATION:	TIGARD			POWELL BOULEVARD				ST. HELENS		STARK			185 & SUNSET		LLOYD CNTR	
LANE NO:	U	L	T	1-H	1-S	2-Z	2-I	A	O	AA	M	N	V	W	D	C
PORTLAND, OREGON	2013	1990	1981	1801	1946	1953	1987	1953	1944	1713	1931	1808	2010	1844	1832	1943

STATION:	MOTOR CIRCLE	
LANE NO:	1	2
RIVERSIDE, CALIF.	2008	2004

SET #2587-01-0179

TABLE 5.2 (Page 5)

HYDROCARBON RESULTS (ppm AS PROPANE)

BLEND NO.: 5 SCOTT ANALYSIS: 3840

STATION:	31ST & LAKESHORE			N. ELSTON AV		W MEDILL AVE		WASHINGTON	
LANE NO:		B		A	B	1A	2B	A	B
CHICAGO, ILLINOIS		3763		3875	4343	3876+	3922+	3178	3897

STATION:	CENTRAL PARKWAY						NORWOOD
LANE NO:	1	2	3	4	5	6	2
CINCINNATI, OHIO	3755	3269	3660	3506	3640	3788	3704

STATION:	AURORA
LANE NO:	1
DENVER, COLORADO	5298

STATION:	SOMERVILLE			MORRISTOWN			RIDGEWOOD		TOM'S RIVER			CAPE MAY	
LANE NO:	100	073	091	045	124	051	055	063	101	102	103	107	106
NEW JERSEY	4115	3636	3769	3923	3887	3887	3885	4000	3769	3846	3774	3846	3846

STATION:	STATE LAB	
LANE NO:	1	Mobile Van
NEW YORK STATE	3774	3715

STATION:	LAB	PHOENIX			MESA			TUCSON		
LANE NO:	---	1	2	3	1	2	3	1	2	3
PHOENIX/TUCSON, AI	3760	3898	3796	3874	3781	3846	3824	3914	3897	3881

STATION:	TIGARD			POWELL BOULEVARD				ST. HELENS		STARK			185 & SUNSET		LLOYD CNTR	
LANE NO:	U	L	T	1-H	1-S	2-Z	2-I	A	O	AA	M	N	V	W	D	C
PORTLAND, OREGON	3676	3800	3704	3511	3538	3486	3569	3729	3738	3446	3585	3390	3810	3724	3477	3528

STATION:	MOTOR CIRCLE	
LANE NO:	1	2
RIVERSIDE, CALIF.	3917	3917

SET #2587-01-0179

TABLE 5.3

CARBON MONOXIDE RESULTS (PERCENT)

BLEND NO.: 1 SCOTT ANALYSIS: < 1 ppm

STATION:	31ST & LAKESHORE			N. ELSTON AV		W MEDILL AVE		WASHINGTON	
LANE NO:		B		A	B	1A	2B	A	B
CHICAGO, ILLINOIS		.08		0.0	0.0	0.0	0.0	.09	.08

STATION:	CENTRAL PARKWAY						NORWOOD
LANE NO:	1	2	3	4	5	6	2
CINCINNATI, OHIO	0	0	0	0	0	0	0

STATION:	AURORA
LANE NO:	1
DENVER, COLORADO	.01

STATION:	SOMERVILLE			MORRISTOWN			RIDGEWOOD		TOM'S RIVER			CAPE MAY	
LANE NO:	100	073	091	045	124	051	055	063	101	102	103	107	106
NEW JERSEY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

STATION:	STATE LAB	Mobile
LANE NO:	1	Van
NEW YORK STATE	0	0

STATION:	LAB	PHOENIX			MESA			TUCSON		
LANE NO:	---	1	2	3	1	2	3	1	2	3
PHOENIX/TUCSON, AI	.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

STATION:	TIGARD			POWELL BOULEVARD				ST. HELENS		STARK			185 & SUNSET		LLOYD CNTR	
LANE NO:	U	L	T	1-H	1-S	2-Z	2-I	A	O	AA	M	N	V	W	D	C
PORTLAND, OREGON	0.0	0.0	0.0	0.0	0.05	0.0	0.5	0.0	0.05	0.0	0.0	0.05	0.0	0.0	0.0	0.0

STATION:	MOTOR CIRCLE	
LANE NO:	1	2
RIVERSIDE, CALIF.	0.0	0.0

SET #2587-01-0179

TABLE 5.3 (Page 2)

CARBON MONOXIDE RESULTS (PERCENT)

BLEND NO.: 2 SCOTT ANALYSIS: .903%

STATION:	31ST & LAKESHORE			N. ELSTON AV		W MEDILL AVE		WASHINGTON	
LANE NO:		B		A	B	1A	2B	A	B
CHICAGO, ILLINOIS		.76		1.0	.9	.9	1.0	.96	.89

STATION:	CENTRAL PARKWAY						NORWOOD
LANE NO:	1	2	3	4	5	6	2
CINCINNATI, OHIO	.980	.90	.980	1.0	.980	.970	.90

STATION:	AURORA
LANE NO:	1
DENVER, COLORADO	.91

STATION:	SOMERVILLE			MORRISTOWN			RIDGEWOOD		TOM'S RIVER			CAPE MAY	
LANE NO:	100	073	091	045	124	051	055	063	101	102	103	107	106
NEW JERSEY	1.0	1.0	.9	.9	.8	1.0	.9	.8	.8	.9	.8	.75	.9

STATION:	STATE LAB	
LANE NO:	1	Mobile Van
NEW YORK STATE	0.9	0.9

STATION:	LAB	PHOENIX			MESA			TUCSON		
LANE NO:	---	1	2	3	1	2	3	1	2	3
PHOENIX/TUCSON, AR	.93	.94	.91	.94	.94	.94	.92	.94	.93	.95

STATION:	TIGARD			POWELL BOULEVARD				ST. HELENS		STARK			185 & SUNSET		LLOYD CNTR	
LANE NO:	U	L	T	1-H	1-S	2-Z	2-I	A	O	AA	M	N	V	W	D	C
PORTLAND, OREGON	.9	.8	.9	.75	.85	.7	.85	.85	.85	.75	.8	.8	.85	.9	.8	.8

STATION:	MOTOR CIRCLE	
LANE NO:	1	2
RIVERSIDE, CALIF.	.96	.97

SET #2587-01-0179

TABLE 5.3 (Page 3)

CARBON MONOXIDE RESULTS (PERCENT)

BLEND NO.: 3 SCOTT ANALYSIS: 2.13

STATION:	31ST & LAKESHORE			N. ELSTON AV		W MEDILL AVE		WASHINGTON	
LANE NO:		B		A	B	1A	2B	A	B
CHICAGO, ILLINOIS		1.68		2.1	2.2	1.9	2.3	2.10	2.15

STATION:	CENTRAL PARKWAY						NORWOOD
LANE NO:	1	2	3	4	5	6	2
CINCINNATI, OHIO	2.2	2.1	2.2	2.2	2.25	2.2	2.0

STATION:	AURORA
LANE NO:	1
DENVER, COLORADO	2.12

STATION:	SOMERVILLE			MORRISTOWN			RIDGEWOOD		TOM'S RIVER			CAPE MAY	
LANE NO:	100	073	091	045	124	051	055	063	101	102	103	107	106
NEW JERSEY	2.0	2.3	2.2	2.1	2.0	2.2	2.0	2.2	1.9	2.1	2.1	1.8	2.3

STATION:	STATE LAB	
LANE NO:	1	Mobile Van
NEW YORK STATE	2.1	2.0

STATION:	LAB	PHOENIX			MESA			TUCSON		
LANE NO:	---	1	2	3	1	2	3	1	2	3
PHOENIX/TUCSON, AR	2.17	2.2	2.16	2.21	2.24	2.19	2.21	2.2	2.15	2.21

STATION:	TIGARD			POWELL BOULEVARD				ST. HELENS		STARK			185 & SUNSET		LLOYD CNTR	
LANE NO:	U	L	T	1-H	1-S	2-Z	2-I	A	O	AA	M	N	V	W	D	C
PORTLAND, OREGON	2.1	2.0	2.1	1.8	2.1	1.7	1.8	2.0	2.05	1.85	1.95	1.85	2.1	2.1	1.9	1.9

STATION:	MOTOR CIRCLE	
LANE NO:	1	2
RIVERSIDE, CALIF.	2.25	2.25

SET #2587-01-0179

TABLE 5.3 (Page 4)

CARBON MONOXIDE RESULTS (PERCENT)

BLEND NO.: 4 SCOTT ANALYSIS: 4.84

STATION:	31ST & LAKESHORE			N. ELSTON AV		W MEDILL AVE		WASHINGTON	
LANE NO:		B		A	B	1A	2B	A	B
CHICAGO, ILLINOIS		3.61		4.7	4.8	4.3	5.4	4.78	4.69

STATION:	CENTRAL PARKWAY						NORWOOD
LANE NO:	1	2	3	4	5	6	2
CINCINNATI, OHIO	5.0	4.75	4.75	4.6	5.0	4.75	4.5

STATION:	AURORA
LANE NO:	1
DENVER, COLORADO	4.72

STATION:	SOMERVILLE			MORRISTOWN			RIDGEWOOD		TOM'S RIVER			CAPE MAY	
LANE NO:	100	073	091	045	124	051	055	063	101	102	103	107	106
NEW JERSEY	5.0	5.2	5.0	5.3	4.8	5.2	4.7	5.0	4.8	4.7	4.6	4.5	5.4

STATION:	STATE LAB	
LANE NO:	1	Mobile Van
NEW YORK STATE	4.6	4.5

STATION:	LAB	PHOENIX			MESA			TUCSON		
LANE NO:	---	1	2	3	1	2	3	1	2	3
PHOENIX/TUCSON, AR	4.85	4.78	4.8	4.98	4.99	4.99	4.9	4.92	4.81	4.89

STATION:	TIGARD			POWELL BOULEVARD				ST. HELENS		STARK			185 & SUNSET		LLOYD CNTR	
LANE NO:	U	L	T	1-H	1-S	2-Z	2-I	A	O	AA	M	N	V	W	D	C
PORTLAND, OREGON	4.2	4.3	4.3	3.95	4.05	4.05	4.15	4.25	4.30	3.85	4.15	3.90	4.4	4.1	4.0	4.2

STATION:	MOTOR CIRCLE	
LANE NO:	1	2
RIVERSIDE, CALIF.	4.97	4.97

TABLE 5.3 (Page 5)

CARBON MONOXIDE RESULTS (PERCENT)

BLEND NO.: 5 SCOTT ANALYSIS: 9.56

STATION:	31ST & LAKESHORE			N. ELSTON AV		W MEDILL AVE		WASHINGTON	
LANE NO:		B		A	B	1A	2B	A	B
CHICAGO, ILLINOIS		7.00		9.2	9.7	8.8	10.0	9.14	9.36

STATION:	CENTRAL PARKWAY						NORWOOD
LANE NO:	1	2	3	4	5	6	2
CINCINNATI, OHIO	10.0	9.75	9.80	9.5	10.4	10.0	9.5

STATION:	AURORA
LANE NO:	1
DENVER, COLORADO	10.27

STATION:	SOMERVILLE			MORRISTOWN			RIDGEWOOD		TOM'S RIVER			CAPE MAY	
LANE NO:	100	073	091	045	124	051	055	063	101	102	103	107	106
NEW JERSEY	9.2	10.2	9.7	9.7	10.0	10.2	9.6	9.9	9.4	9.2	9.5	8.3	10.4

STATION:	STATE LAB	Mobile Van
LANE NO:	1	
NEW YORK STATE	9.3	9.0

STATION:	LAB	PHOENIX			MESA			TUCSON		
LANE NO:	---	1	2	3	1	2	3	1	2	3
PHOENIX/TUCSON, AR	9.45	9.48	9.41	9.75	9.85	9.77	9.55	9.78	9.41	9.60

STATION:	TIGARD			POWELL BOULEVARD				ST. HELENS		STARK			185 & SUNSET		LLOYD CNTR	
LANE NO:	U	L	T	1-H	1-S	2-Z	2-I	A	O	AA	M	N	V	W	D	C
PORTLAND, OREGON	8.3	8.6	8.5	8.0	7.85	7.8	8.4	8.35	8.65	8.1	8.1	7.5	8.8	8.6	7.8	7.9

STATION:	MOTOR CIRCLE	
LANE NO:	1	2
RIVERSIDE, CALIF.	9.58	9.55

SET #2587-01-0179

The following are brief descriptions of each I/M program based on background information obtained during the field evaluations. Included are descriptions of the calibration procedures used by each program and summaries of instrument maintenance:

Chicago Department of Environmental Control - Chicago currently conducts voluntary inspections of all types of motor vehicles. The I/M instrumentation is housed in testing vans, with each van supporting two test lanes. Presently, there are five permanent stations and nine mobile stations. Vehicles are tested for hydrocarbons and carbon monoxide at high and low idle. The test cycle is regulated by computer. After data about the vehicle is entered into the computer, the sample probe is inserted into the exhaust pipe and electronic connections are made to the engine. HC and CO emissions are then measured at low and high idle. The computer determines pass or fail and issues a clean air certificate if the vehicle passes.

The instruments are calibrated daily using electronic calibration. Calibration with gas is done once a week using 1400 and 600 ppm hexane and 2.5% carbon monoxide calibration gases. Calibration gases are not maintained with the vans. Benster Welding Supply was the calibration gas supplier at the time of the field visit.

Routine maintenance of the instruments is handled by Chicago personnel. More extensive maintenance or repairs are performed by the instrument manufacturer, Sun Electric Corporation. The instruments are estimated to be fully operational 84% of the time. The program maintenance records did not reveal any chronic instrument problems. One instrument was found to have a leaking sample system during the field evaluation.

Cincinnati Division of Air Pollution Control - The Cincinnati I/M program involves mandatory annual inspections of vehicles up to 6,000 pounds gross vehicle weight, with emission testing for hydrocarbons and carbon monoxide at idle only. Vehicles are subjected to a general safety test, including brakes, tires, lights and glass. HC and CO emissions are then measured at idle. Vehicles passing are given window stickers. Vehicles failing the tests must return within 30 days for a retest.

Calibration, maintenance and repairs of the instruments are performed by the instrument manufacturer, Sun Electric Corporation. The instruments are calibrated once a month by Sun using approximately 900 ppm hexane and 2.5% carbon

monoxide calibration gases. Calibration gases are not maintained at the stations. Liquid Carbonics is the gas supplier.

Cincinnati reports that their instruments have required very little maintenance and are operational nearly 100% of the time. Instrument repairs in 1978 included repairing three instrument pumps and replacing one infrared bench.

Colorado Department of Health - The Colorado I/M program in Denver consists of one permanent and one mobile station. Automobiles and pickup trucks are tested on a voluntary basis for hydrocarbons, carbon monoxide, and nitrogen oxides. Both the permanent and mobile stations are equipped with dynamometers and test vehicles under the Clayton Keymode Procedure, idle, high cruise, low cruise, and idle. The mobile station was not operational at the time of the field visit by Scott.

The instruments are zeroed and spanned with calibration gas prior to each vehicle test. Prior to the audit, the instruments were calibrated with 730.7 ppm propane and 3.99% CO. The instruments are also curve-checked using various levels of gases occasionally. The calibration gases are cross-checked against EPA standard gases in Denver. The span gases are supplied by Scientific Gas Products. The gases originally used to determine the instrument curves were supplied by Scott, although they currently use gases from several suppliers. Denver is the only program currently using a flame ionization detector for hydrocarbons. They are planning to use an infrared instrument in the near future. Hydrocarbon results are reported as ppm carbon (C_1) and ppm hexane (C_6) using a factor of 1/10.8 to convert from the ppm carbon reading to a hexane reading roughly equivalent to what would be obtained using an infrared instrument. In general, higher readings of hydrocarbons in vehicle exhaust are obtained with a F.I.D. than with an N.D.I.R. This is the reason a factor of 10.8 is used rather than 6 to convert from C_1 to C_6. However, both instruments should give the same reading when analyzing propane. Therefore, for this audit, the ppm carbon reading was divided by 3 to obtain ppm as propane (C_3). It is not known why there is such a large difference between the standard gases and the hydrocarbon reading.

The instruments are estimated to be operational 90% of the time. The hydrocarbon and carbon monoxide have only required routine maintenance. Repairs of the nitrogen oxides instrument have included replacement of the ozonator

approximately every four months, and replacement of the photomultiplier tube in the mobile instrument about once a year (possibly because of vibration).

New Jersey Department of Environmental Protection - New Jersey operates a mandatory I/M program throughout the state. Vehicles up to 6,000 pounds gross vehicle weight are tested annually for hydrocarbon and carbon monoxide emissions. Testing is done at idle only. The vehicle test includes a complete safety check, including wheel bearings, lights, horn, wipers, and brakes. Vehicles failing the emission test may be retested at licensed private inspection centers for certification.

The instruments are calibrated using gas twice a month. 2800 ppm propane and 7% CO calibration gas is used. The instrument zero is checked electronically before each vehicle test and the span is checked electronically every two hours. The calibration gases are supplied by Scott Specialty Gases.

Routine maintenance is performed by New Jersey personnel. The state also has an agreement with the instrument manufacturer, Sun Electric Corporation, for a fixed number of service calls (30) each month. There are no major maintenance problems and instrument availability is close to 100%. During the field evaluation, low ambient temperatures (20°F) appeared to cause instrument drift problems. New Jersey will be upgrading their instrumentation in the near future.

New York State Department of Environmental Conservation - New York is currently only doing vehicle emission testing of a control group of 250 cars to further define the relationship of the state of tune to emissions. Testing is done at the state laboratory in Latham, New York for hydrocarbons and carbon monoxide. Nitrogen oxide emissions will also be measured in the future. Vehicles are tested at idle and high cruise. From 1972 to 1976, a voluntary I/M program was conducted throughout the state using a mobile van. Vehicles were tested at idle.

The instruments are generally calibrated electronically several times a day and with calibration gas once a day, with 3080 ppm propane and 8.0% CO calibration gas. Scott Specialty Gases is the manufacturer. Problems have been experienced with the zero and span potentiometers. Major maintenance has consisted of replacing the infrared benches in April 1975 and in January 1977. The instruments showed drift at low ambient temperatures similar to that experienced by the New Jersey instruments.

Arizona Bureau of Vehicular Emissions Inspection - The State of Arizona operates a mandatory I/M program in Phoenix and Tucson metropolitan areas (Maricopa and Pima counties). The program is conducted by a private contractor, Hamilton Test Systems. The state also operates a vehicle testing laboratory which maintains gas standards for the I/M program and does research on vehicles which consistently fail the inspections.

All types of vehicles are tested in the I/M program, including automobiles, motorcycles, and diesel trucks. Vehicles are tested at high cruise, low cruise, and idle on a dynamometer for emissions of hydrocarbons and carbon monoxide. Diesel trucks are inspected for exhaust opacity only. The emissions test is regulated by computer. Test results are printed out by the computer based on vehicle make, model, and engine data and idle emissions. The test includes a tire safety check and an under hood check to verify that the emission control equipment is properly installed.

The instruments are zeroed and spanned with calibration gas once a week by station personnel. The calibration is checked every two weeks by Arizona personnel. Calibration gases are checked against standards maintained by the state laboratory. 467, 1787 and 19,700 ppm propane, and 1.6 and 7.9% CO calibration gases were last used by the state. Liquid Carbonics supplies the calibration gases. The instrument computer automatically verifies that the instrument zeros are under 40 ppm for hydrocarbons and 0.5% for carbon monoxide, before each test. The span is also checked between tests by the computer by the presence of constant voltage through the instrument electronics. The instruments include an extended range to 20,000 ppm hydrocarbons to test motorcycles. No instrument maintenance problems have been encountered. Instrument availability is nearly 100% with instrument down-time estimated at 30 minutes per month.

Instruments used in the state laboratory are calibrated before each test. Both vehicle exhaust and calibration gases are tested by the laboratory. The laboratory has experienced a long term drift problem with a Horiba A1A-21 hydrocarbon/carbon monoxide instrument.

Oregon Department of Environmental Quality - The Oregon I/M program is a mandatory program operated in the Portland metropolitan area. All types of gasoline engines, except motorcycles, are tested for hydrocarbon and carbon monoxide emissions. Emission measurements are made at low idle, high idle, and again at low idle. Results are based on the lower of the readings at low idle. Vehicles are tested every two years.

The instruments are calibrated every hour using 3233 ppm propane and 7.1% CO calibration gas. Airco is the gas supplier. The instruments at each station are checked daily between each other by inserting the probes from all instruments into the same vehicle tailpipe. The instruments at all the stations are also checked once or twice per month with cross-reference gas by the program headquarters on an unannounced basis. The only maintenance problems with the instruments have been related to the sampling systems. Accumulation of dirt have caused hang-up and zeroing problems with the instruments. Generally, only normal maintenance has been required.

California Bureau of Automotive Repair - California has operated two I/M stations in Riverside, California to voluntarily test automobiles and pickup trucks since 1975. The program has currently been suspended, to be replaced with a mandatory program scheduled to begin in 1979. During the audit, only two lanes at one station were operating. Vehicles are tested for hydrocarbons, carbon monoxide, and nitrogen oxides at high cruise, low cruise, and idle, on a dynamometer. The vehicle test includes a check of safety equipment and emission control equipment. A computer regulates the emissions test and prints results based on the idle reading.

The instruments are spanned daily using calibration gas. The computer system automatically checks instrument zero before each vehicle test and checks span every tenth vehicle test. All lanes are also cross-checked daily by calibration gas introduced through the sampling probes. Once per month the analyzers are curve-checked against varying levels of calibration gas. 1158 ppm propane and 6.08% CO calibration gas manufactured by Scott Specialty Gases was used to span the instruments before the audit.

The California records show an overall instrument availability of 97.3%. No major instrument problems have been encountered. Instrument down-time has been for routine maintenance and calibration.

After the completion of the field visits, one set of the gases was shipped to the Portland program for reanalysis. The purpose of the reanalysis was to help in diagnosing the reason the CO results were consistently low. The results of the reanalysis by Unit Y are shown in Table 5.4. Although the CO results are still somewhat low for the higher concentrations, the hydrocarbon results closely agree with the standard gases. The reason for the low CO results is not known at this time.

TABLE 5.4

RESULTS OF REANALYSIS BY PORTLAND
UNIT Y - PROPANE/HEXANE FACTOR = 0.532

HC (ppm as C_3)		CO (%)	
Unit Y	Standard Gas	Unit Y	Standard Gas
10	0	0, 0.5, 0	0
375	388	1.05	0.903
817	821	2.35	2.13
1954	1960	4.5, 4.55	4.84
3760 (meter pegged)	3840	9.05, 9.1	9.56

6.0 DATA ANALYSIS OF RESULTS

Data analysis of the audit results includes calculations of the difference between the instrument readings and Scott's analysis of the standard gases and graphical comparisons of the instrument readings for each program to the standard gases. The results are also compared by analysis of variance to determine significant differences between the results from the different programs, station sites, and makes of analyzers.

The overall average difference between the analyzers and the standard gases was about 6% for measuring both hydrocarbons and carbon monoxide. Excluding the CO results from the Portland program results in an overall difference in CO readings of 5%. Table 6.1 shows the average difference from the standard gases for hydrocarbon and carbon monoxide measurements for each of the programs. (The overall differences are weighted averages based on the number of instruments.) The differences in the readings of the zero gas were excluded from the averages. These averages are only intended to provide a rough approximation of the results. The graphical results provide a better indication of each program's accuracy. The instruments in Cincinnati and Portland consistently read low on the higher concentrations of hydrocarbons, and the instruments in New York and Portland were consistently low in reading carbon monoxide.

TABLE 6.1

Summary of the Average Differences Between Instrument Readings and the Standard Gases

	Average Difference From Standard Gases, %*	
Program	Hydrocarbons	Carbon Monoxide
Chicago	9.2	7.1
Cincinnati	6.8	4.3
Denver	22 **	2.7
New Jersey	6.4	5.6
New York State	3.3	3.5
Phoenix/Tucson	3.5	2.5
Portland	4.5	11.4
Riverside	2.3	3.8

*Instrument accuracy is generally expressed as a percentage of full scale, but these differences are actual average percentage differences.

** Flame Ionization Analyzer.

Graphs were prepared to compare the I/M station instrument responses to the standard gases. Figures 6.1 through 6.8 show the graphs for the hydrocarbon

FIGURE 6.1

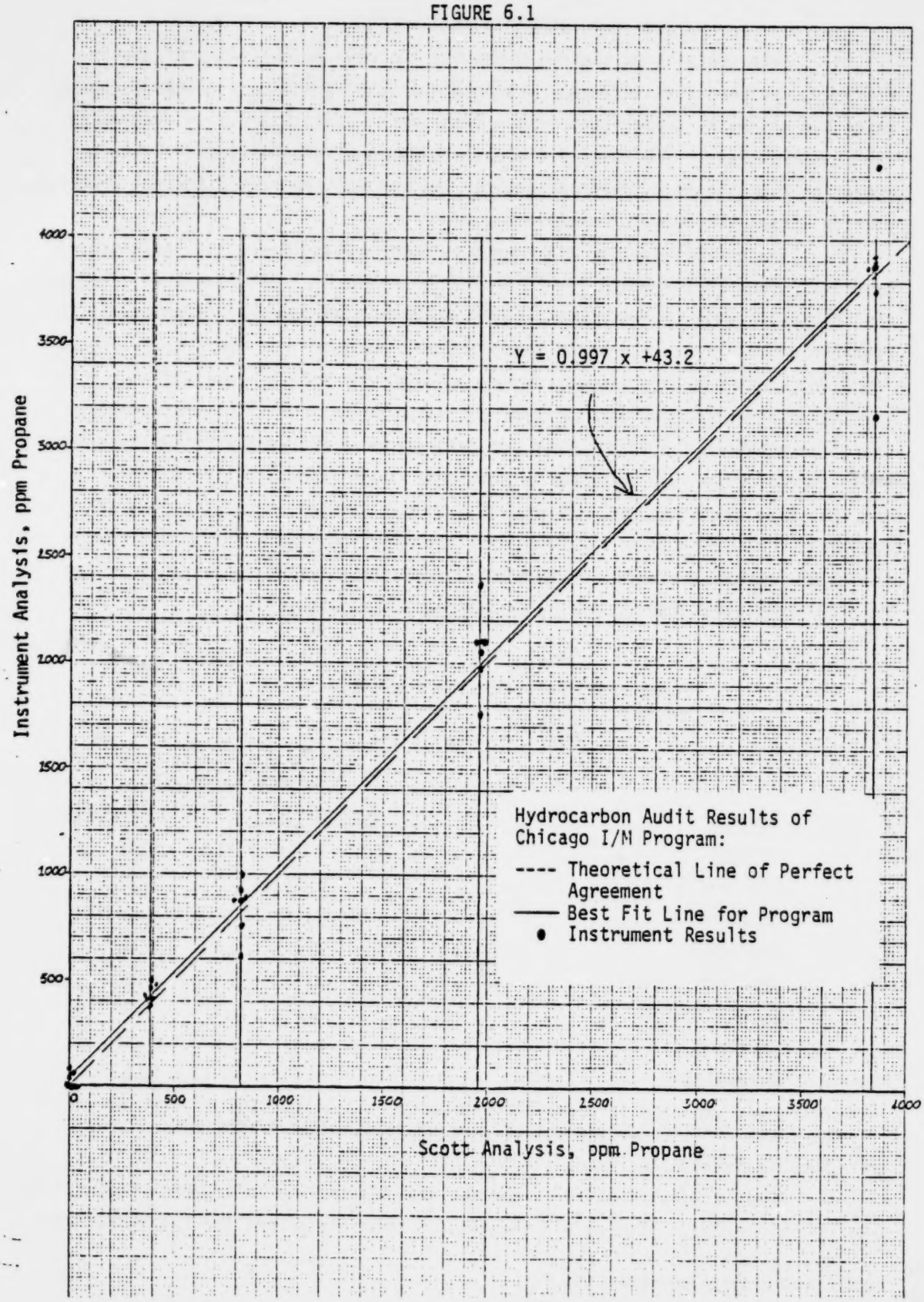
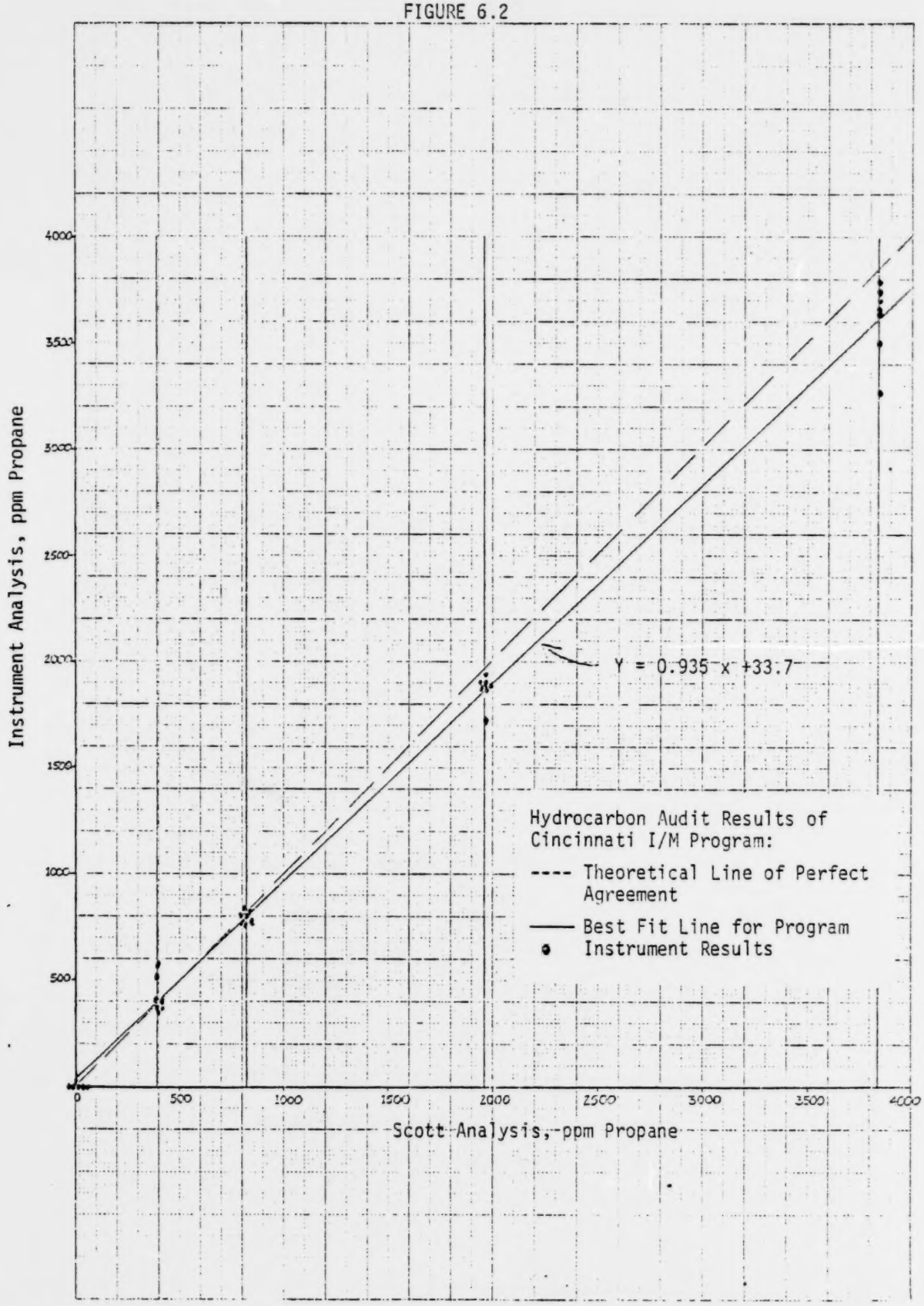

Y = 0.997 x +43.2
Hydrocarbon Audit Results of Chicago I/M Program:
---- Theoretical Line of Perfect Agreement
—— Best Fit Line for Program
• Instrument Results
Instrument Analysis, ppm Propane
Scott Analysis, ppm Propane
0
500
1000
1500
2000
2500
3000
3500
4000

FIGURE 6.2


Instrument Analysis, ppm Propane
4000
3500
3000
2500
2000
1500
1000
500
0
500
1000
1500
2000
2500
3000
3500
4000
Scott Analysis, ppm Propane
Y = 0.935 x +33.7
Hydrocarbon Audit Results of Cincinnati I/M Program:
---- Theoretical Line of Perfect Agreement
—— Best Fit Line for Program
Instrument Results

SET #2587-01-0179

FIGURE 6.3

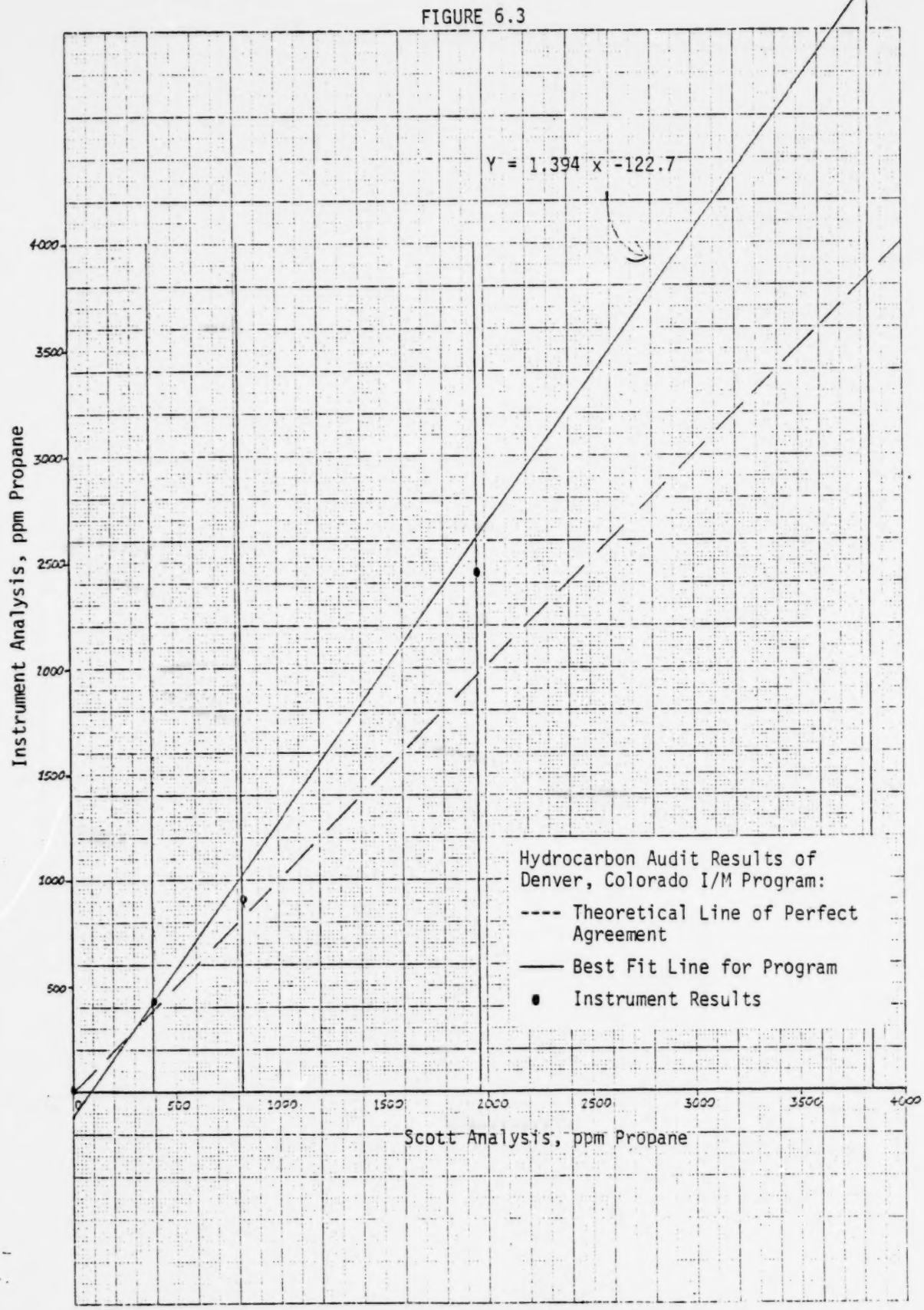


FIGURE 6.4

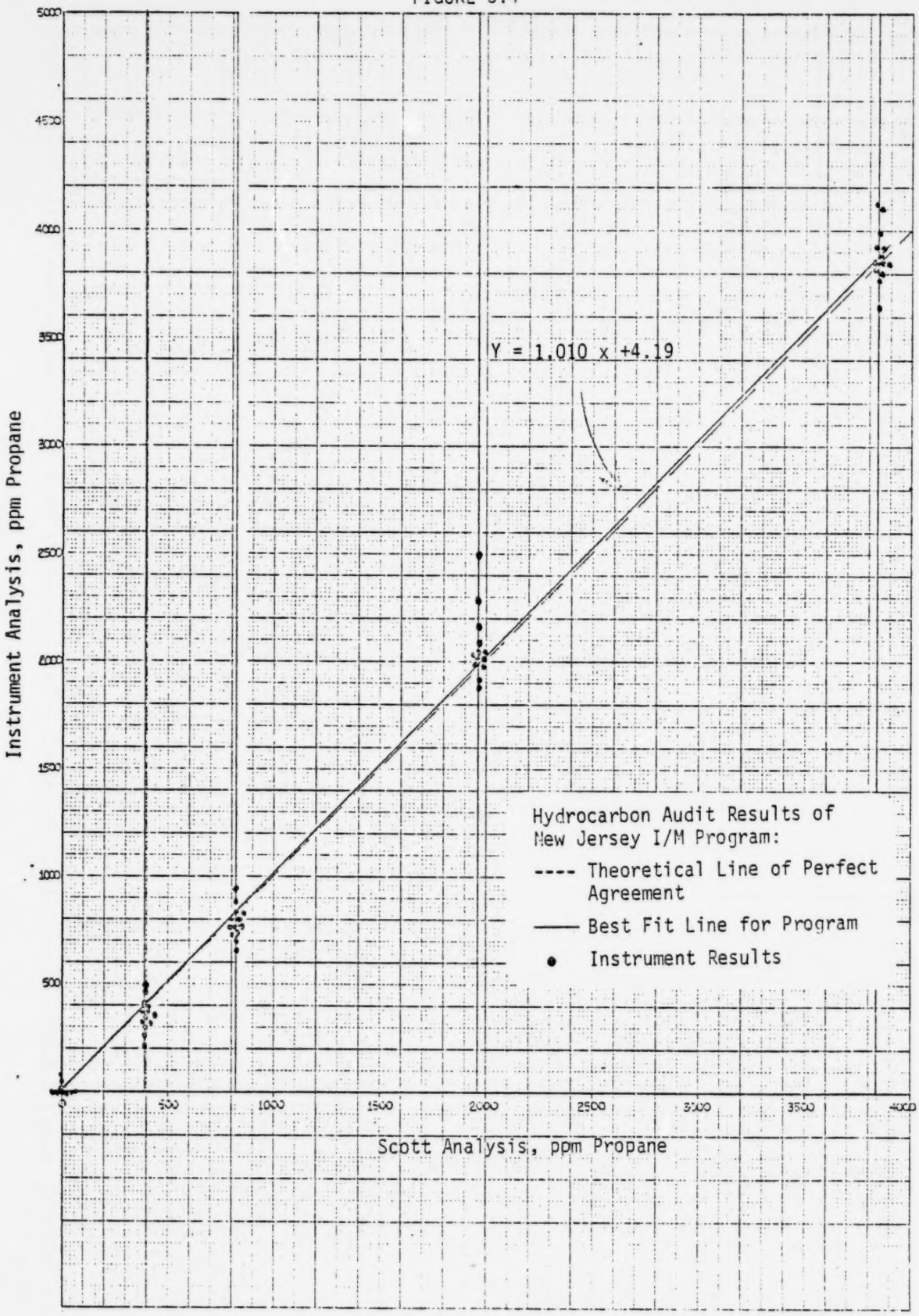

Y = 1.010 x +4.19
Hydrocarbon Audit Results of New Jersey I/M Program:
---- Theoretical Line of Perfect Agreement
—— Best Fit Line for Program
• Instrument Results
Instrument Analysis, ppm Propane
Scott Analysis, ppm Propane
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

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FIGURE 6.5

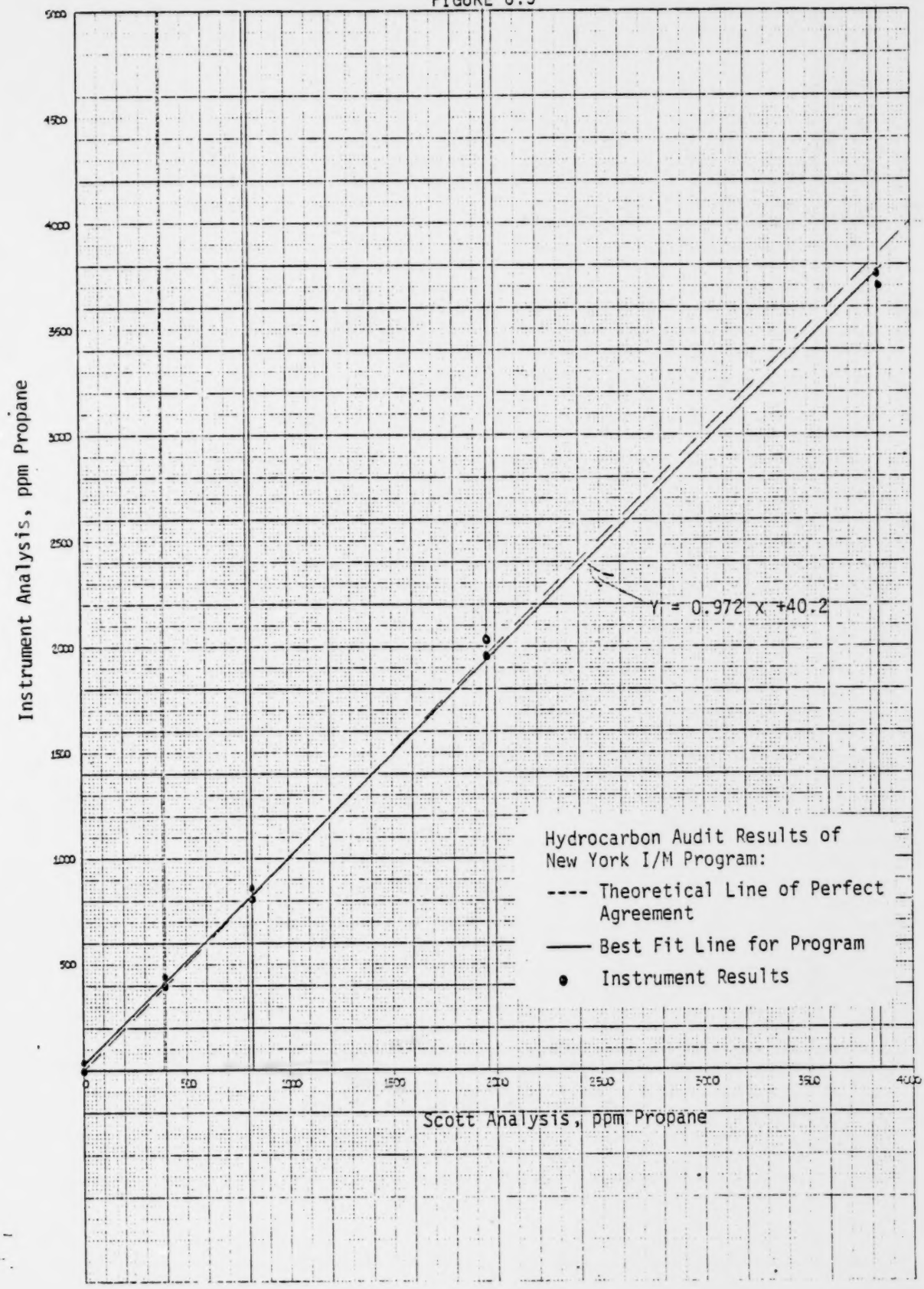

FIGURE 6.6

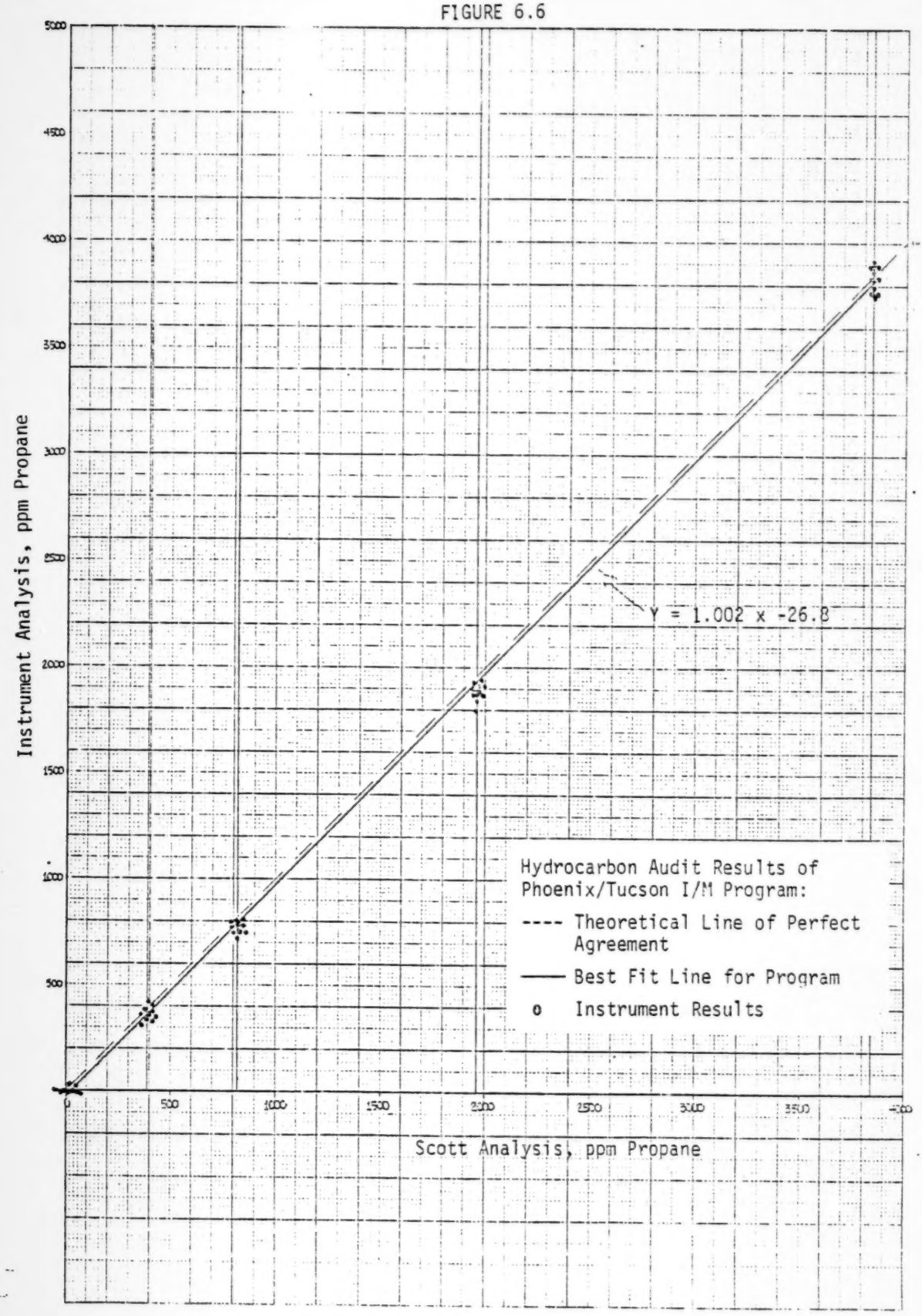
Instrument Analysis, ppm Propane
Scott Analysis, ppm Propane
Y = 1.002 x -26.8
Hydrocarbon Audit Results of Phoenix/Tucson I/M Program:
---- Theoretical Line of Perfect Agreement
—— Best Fit Line for Program
o Instrument Results

FIGURE 6.7

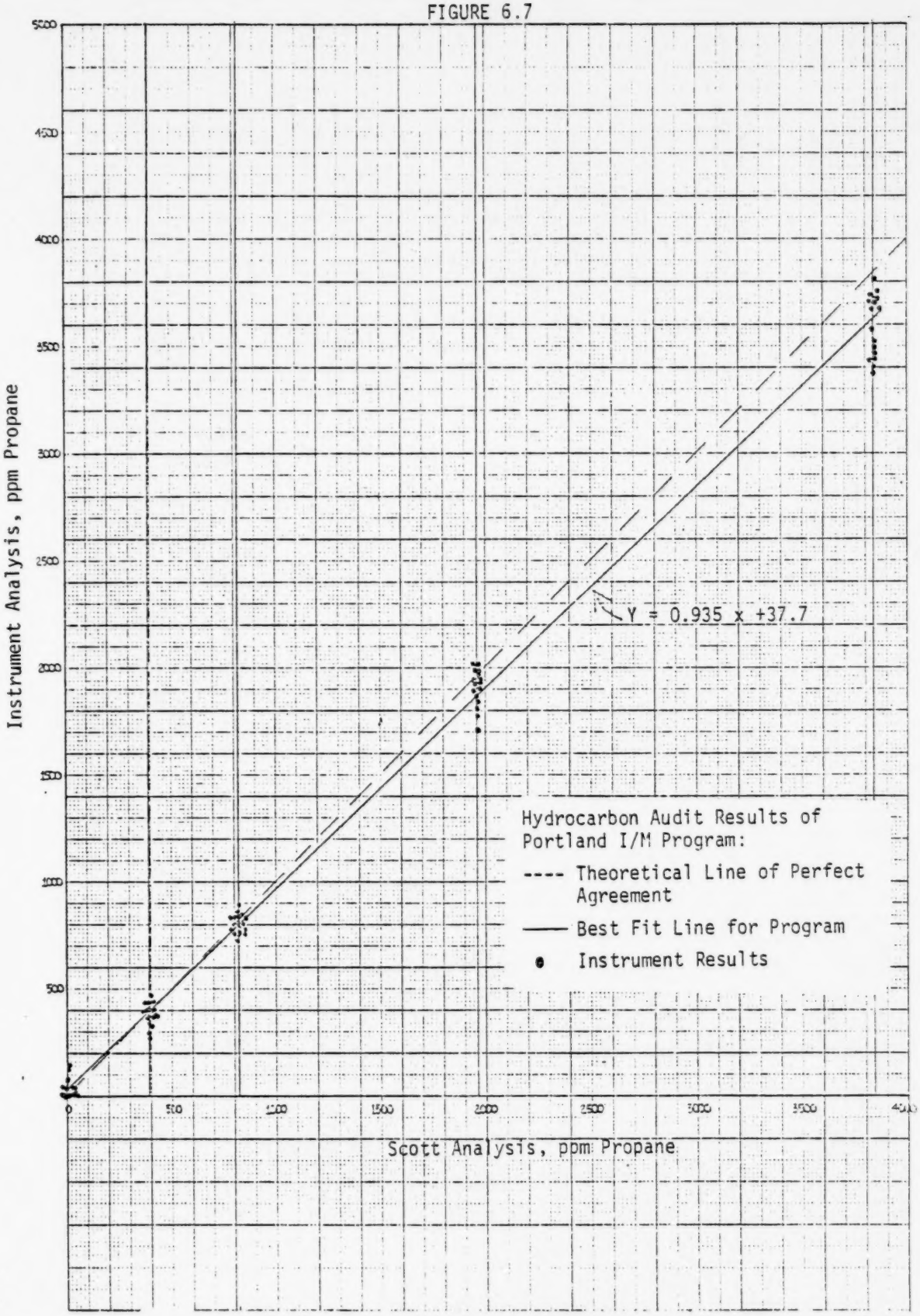
Instrument Analysis, ppm Propane
Scott Analysis, ppm Propane
Y = 0.935 x +37.7
Hydrocarbon Audit Results of Portland I/M Program:
---- Theoretical Line of Perfect Agreement
—— Best Fit Line for Program
• Instrument Results

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FIGURE 6.8

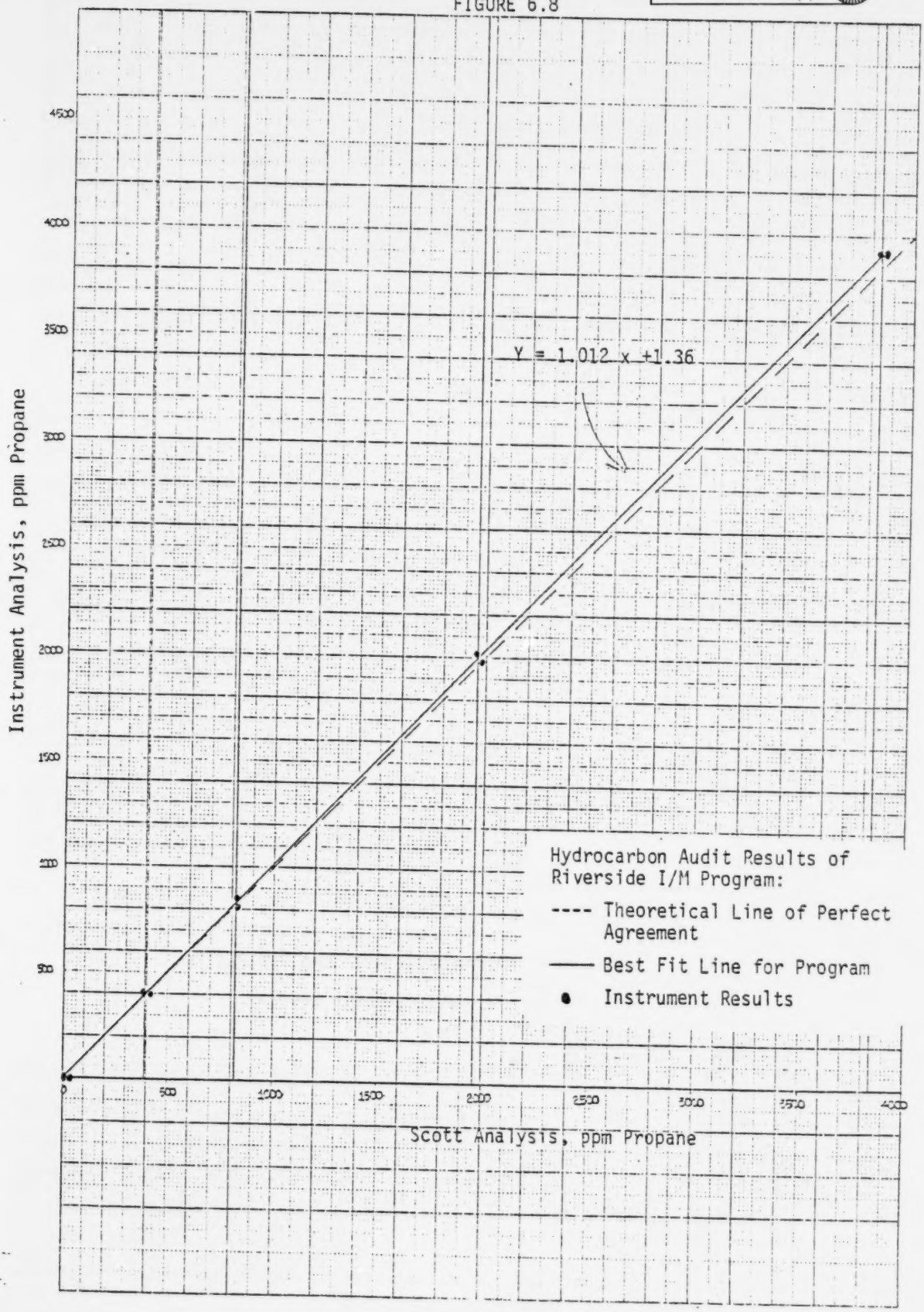

FIGURE 6.9

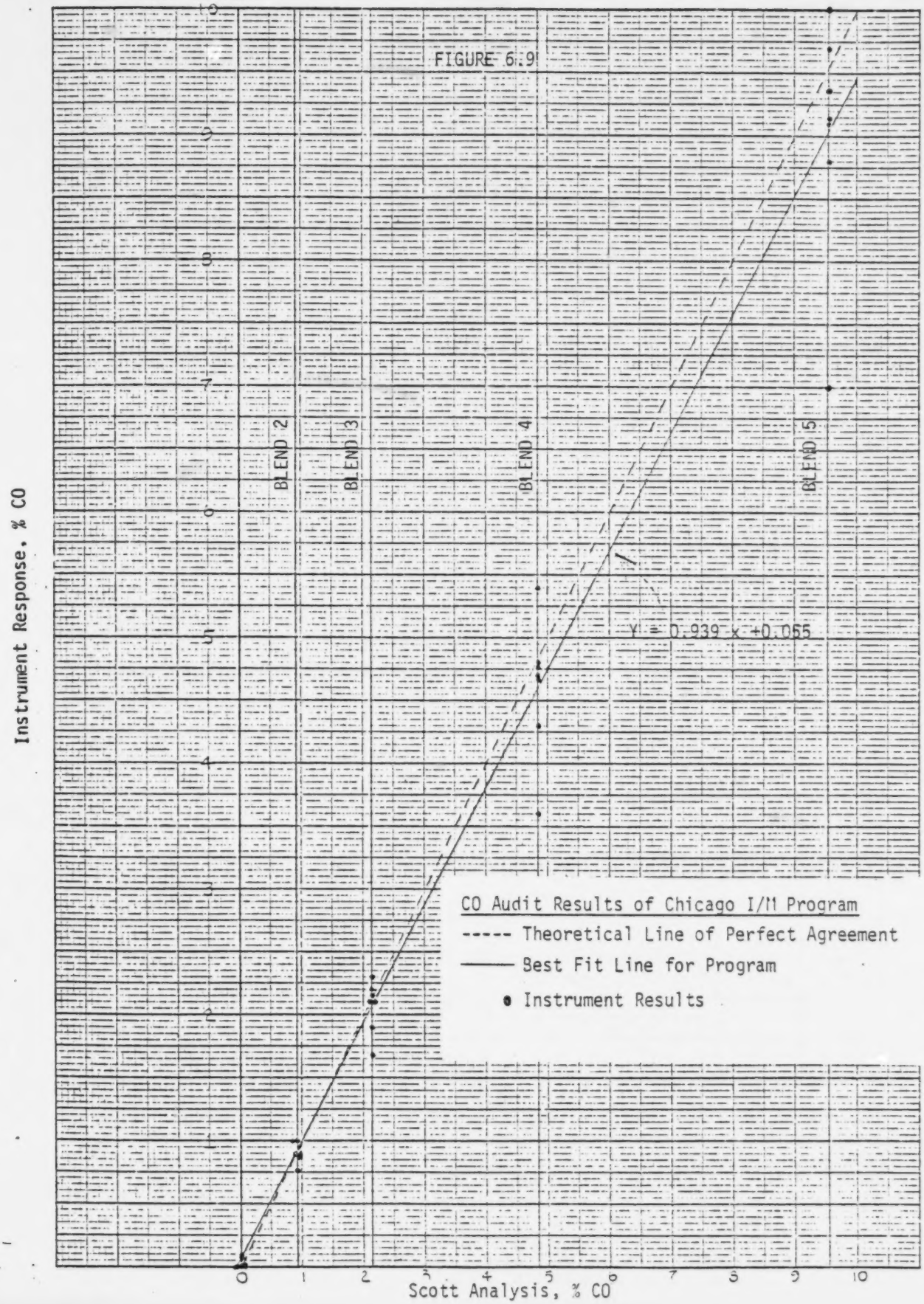
BLEND 2
BLEND 3
BLEND 4
BLEND 5
Y = 0.939 x +0.055
Instrument Response, % CO
Scott Analysis, % CO
0
1
2
3
4
5
6
7
8
9
10
CO Audit Results of Chicago I/M Program
----- Theoretical Line of Perfect Agreement
——— Best Fit Line for Program
• Instrument Results

FIGURE 6.10

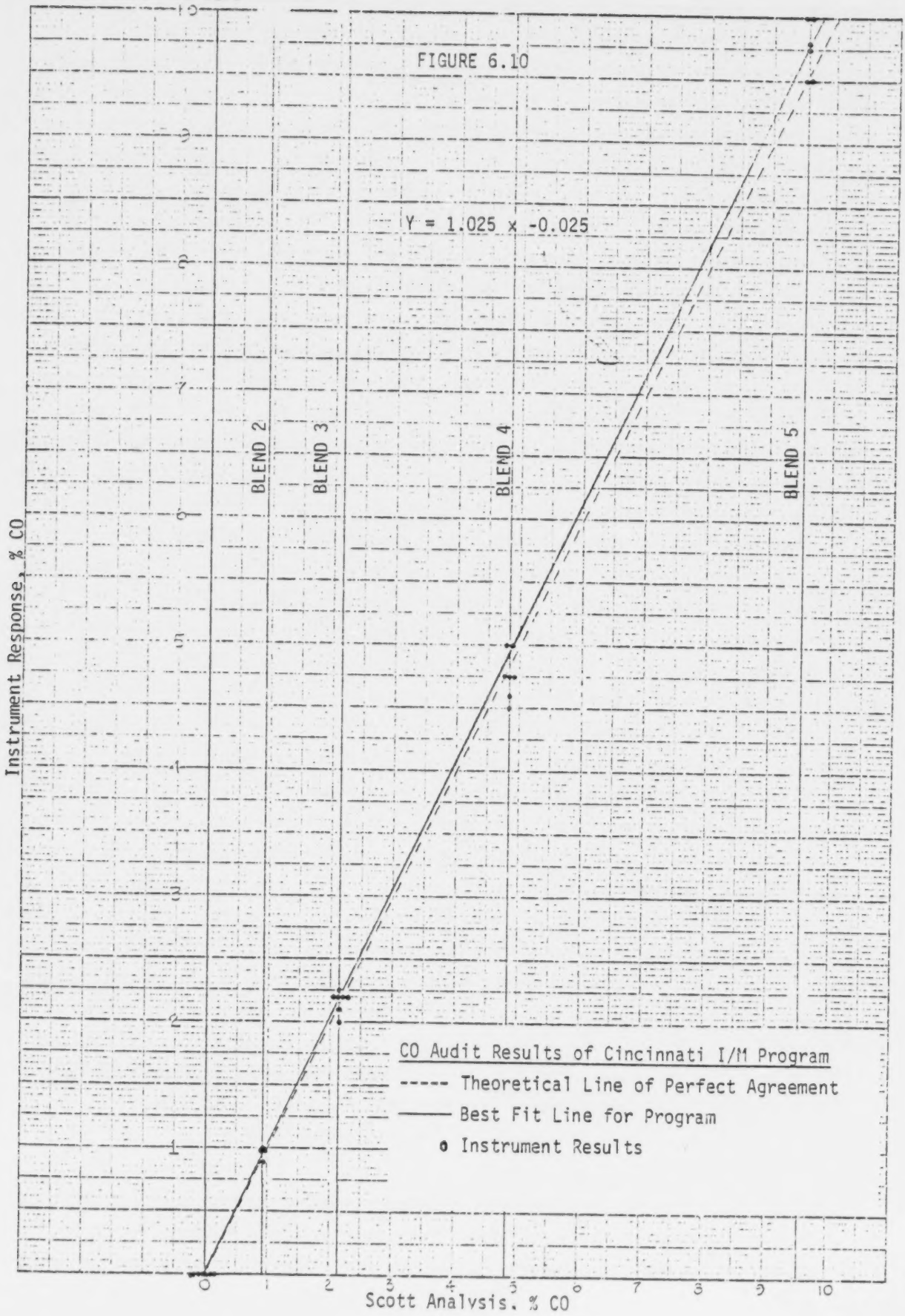
Y = 1.025 x -0.025
BLEND 2
BLEND 3
BLEND 4
BLEND 5
Instrument Response, % CO
Scott Analysis, % CO
0
1
2
3
4
5
6
7
8
9
10
CO Audit Results of Cincinnati I/M Program
----- Theoretical Line of Perfect Agreement
——— Best Fit Line for Program
o Instrument Results

FIGURE 6.11

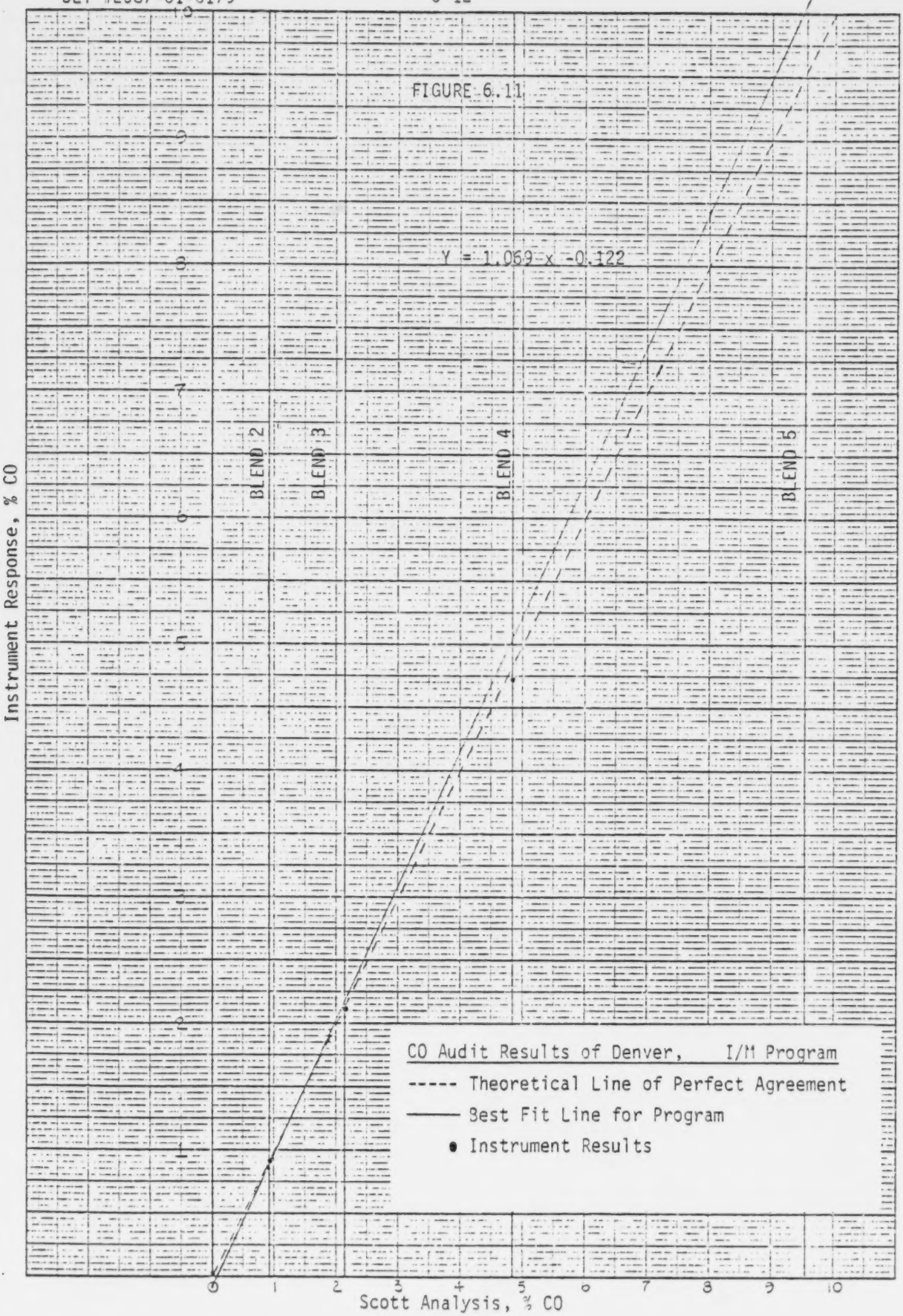
Y = 1.069 x -0.122
BLEND 2
BLEND 3
BLEND 4
BLEND 5
Instrument Response, % CO
Scott Analysis, % CO
0
1
2
3
4
5
6
7
8
9
10
CO Audit Results of Denver, I/M Program
----- Theoretical Line of Perfect Agreement
——— Best Fit Line for Program
• Instrument Results

FIGURE 6.12

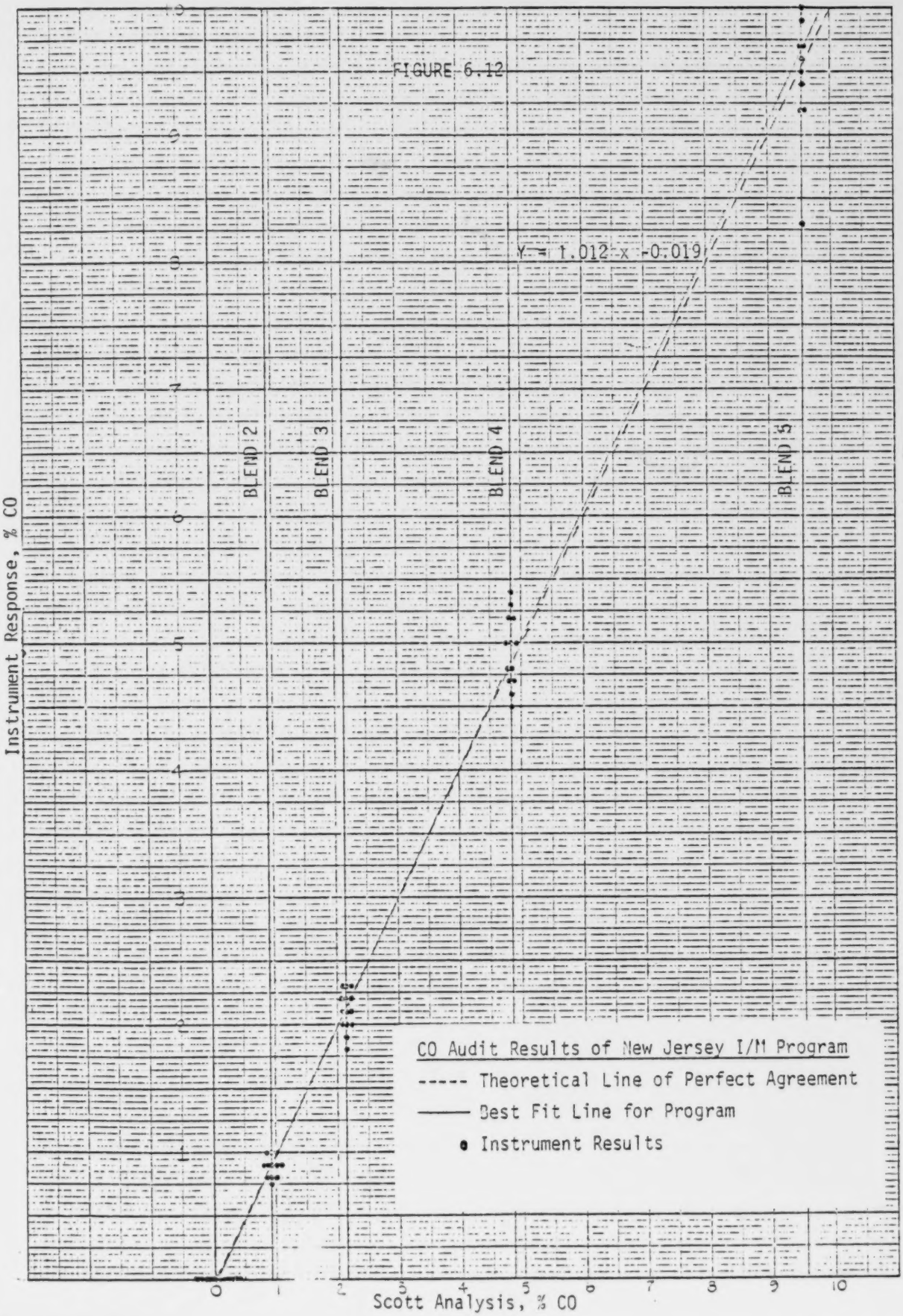

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FIGURE 6.13

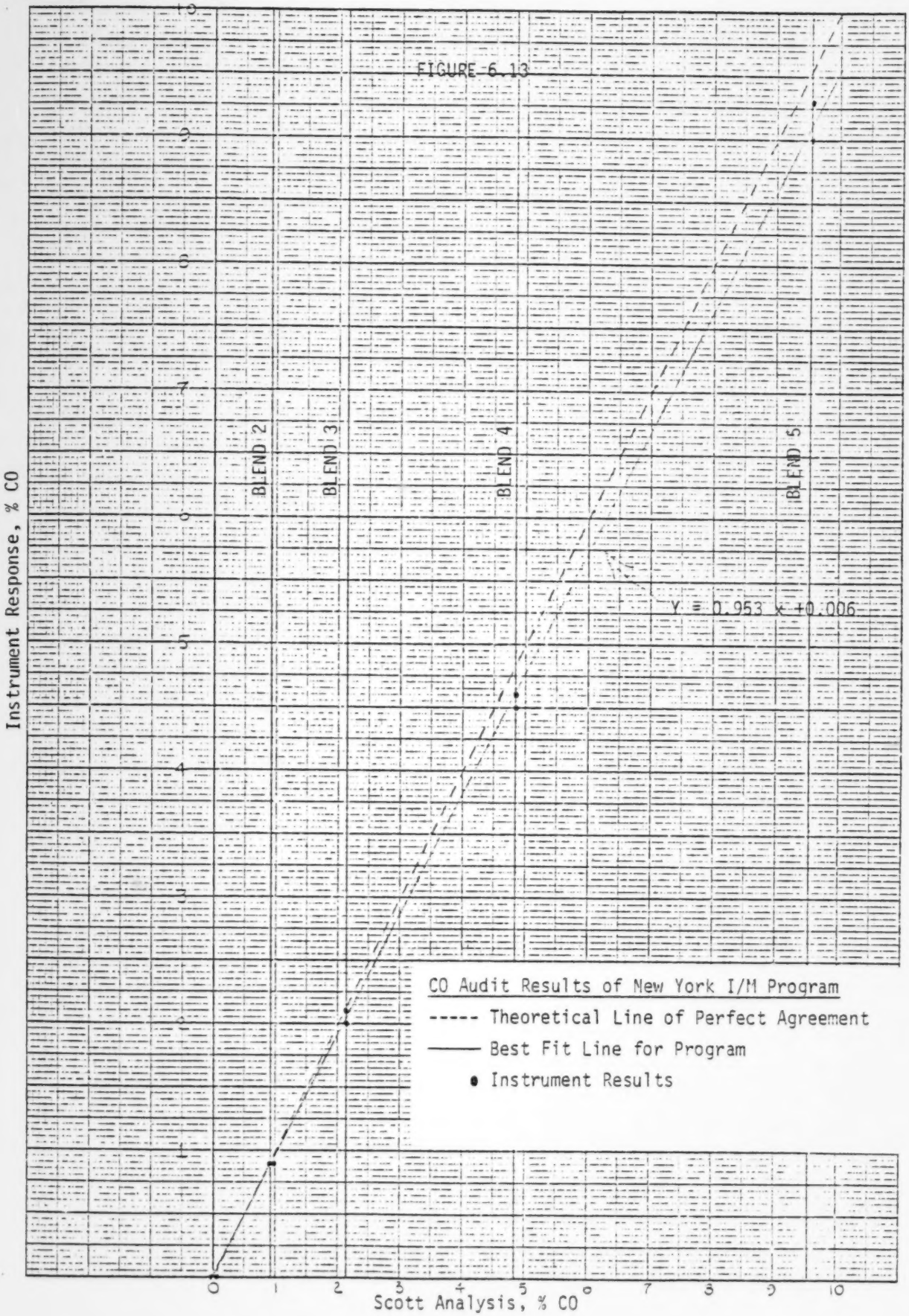

Instrument Response, % CO
Scott Analysis, % CO
BLEND 2
BLEND 3
BLEND 4
BLEND 5
Y = 0.953 x +0.006
CO Audit Results of New York I/M Program
----- Theoretical Line of Perfect Agreement
——— Best Fit Line for Program
• Instrument Results

FIGURE 6.14

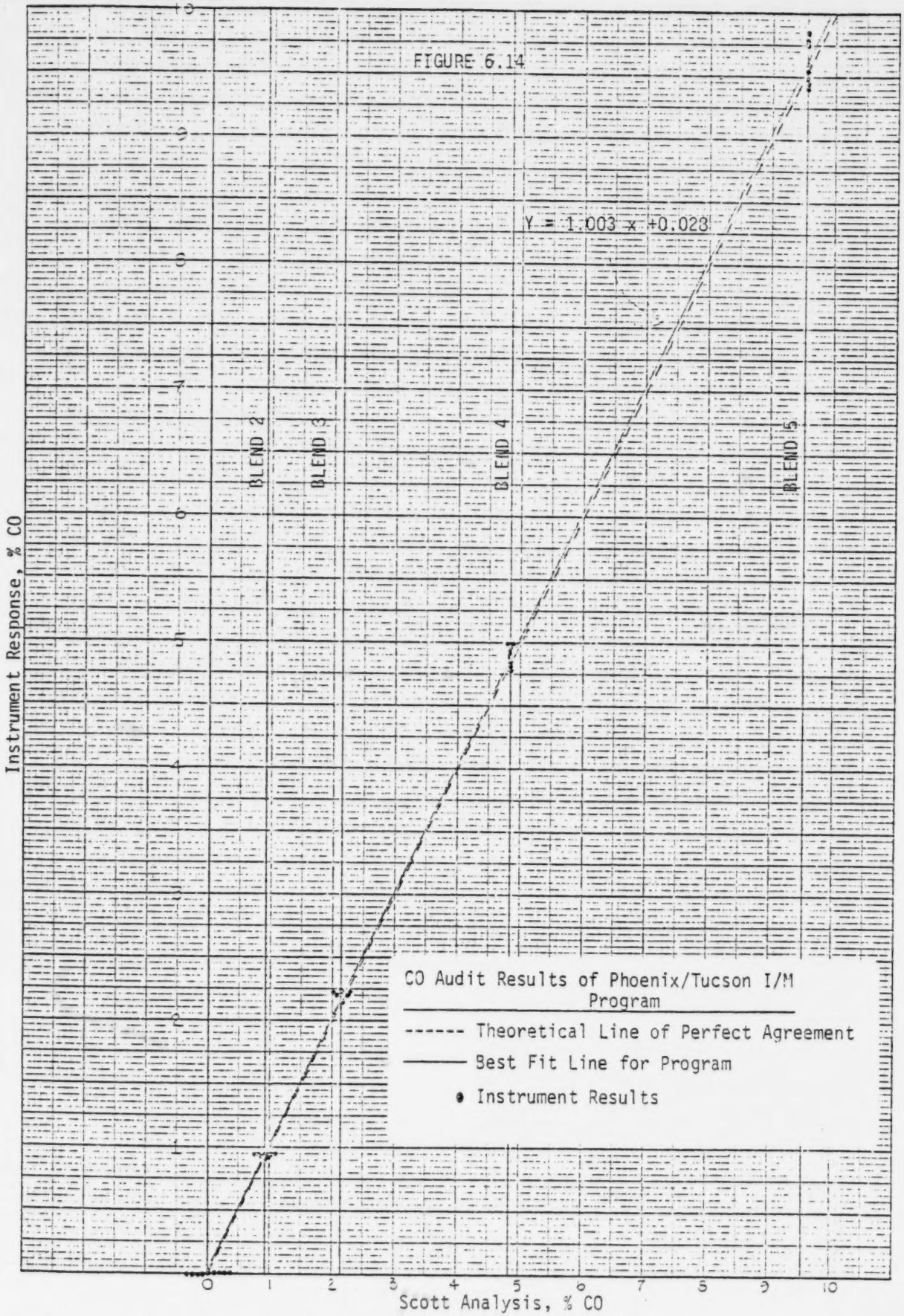

Y = 1.003 x +0.028
BLEND 2
BLEND 3
BLEND 4
BLEND 5
Instrument Response, % CO
Scott Analysis, % CO
0
1
2
3
4
5
6
7
8
9
10
CO Audit Results of Phoenix/Tucson I/M Program
Theoretical Line of Perfect Agreement
Best Fit Line for Program
Instrument Results

FIGURE 6.15

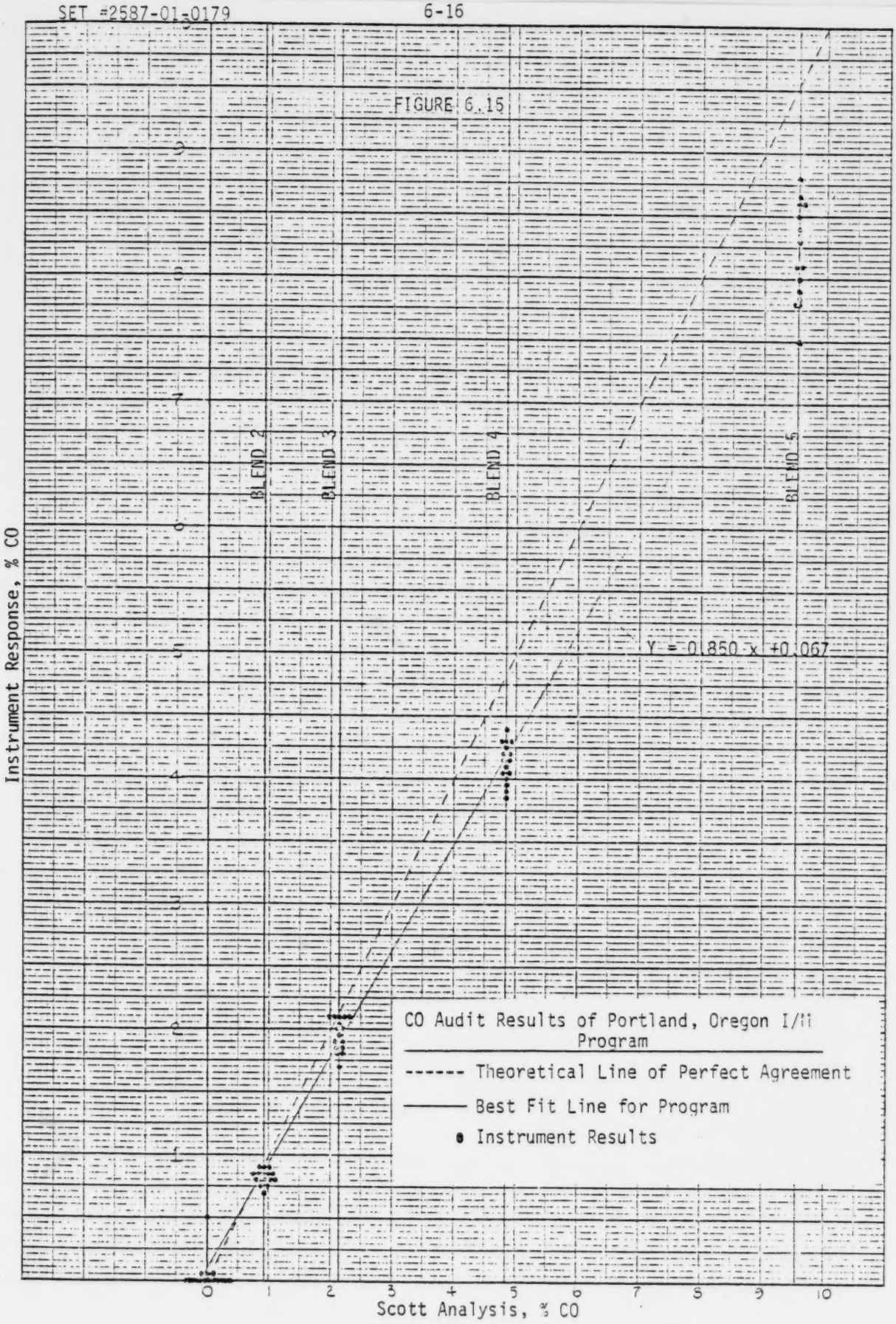
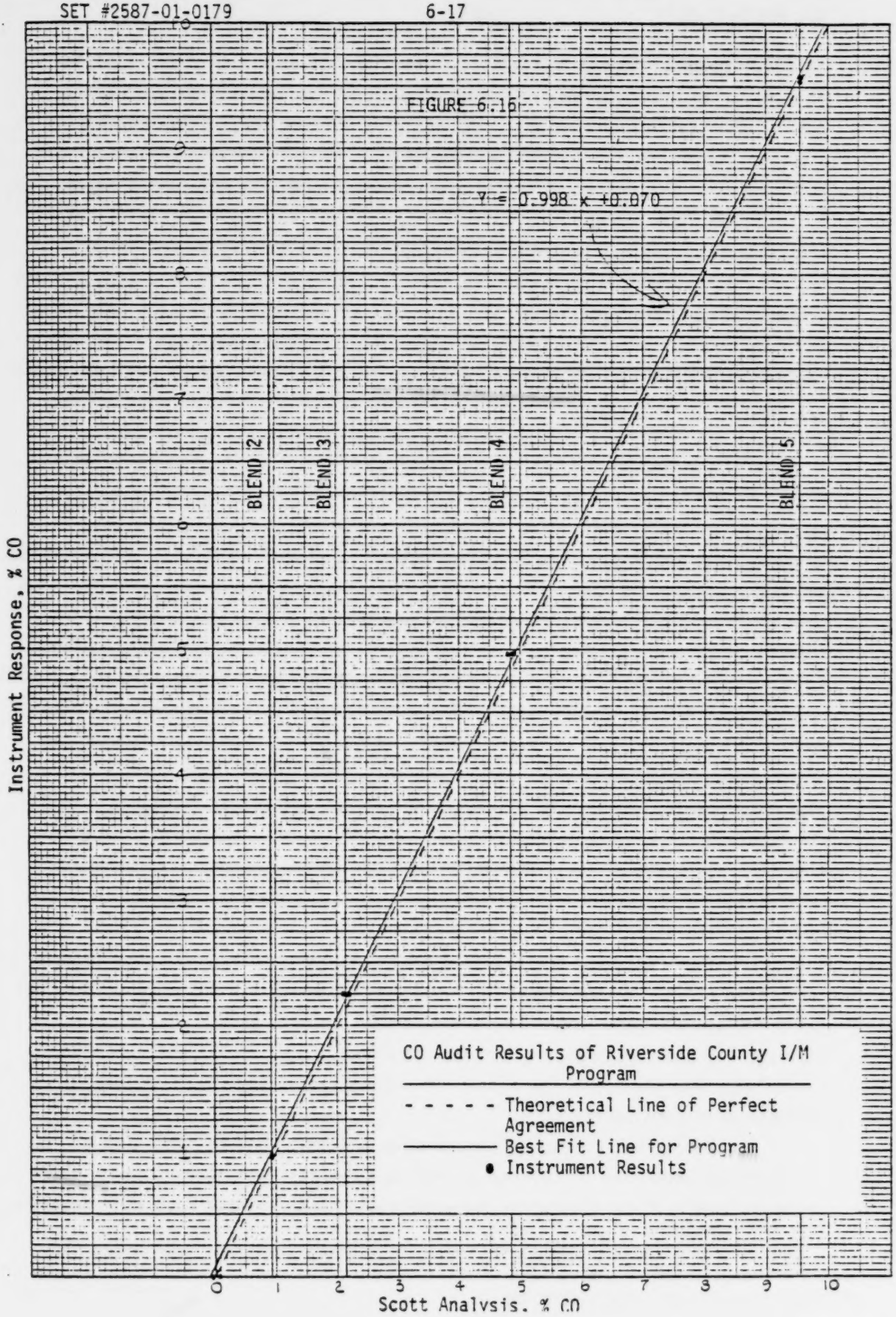

BLEND 2
BLEND 3
BLEND 4
BLEND 5
Y = 0.850 x + 0.067
Instrument Response, % CO
Scott Analysis, % CO
0
1
2
3
4
5
6
7
8
9
10
CO Audit Results of Portland, Oregon I/M Program
Theoretical Line of Perfect Agreement
Best Fit Line for Program
Instrument Results

FIGURE 6.16



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results for each program. Figures 6.9 through 6.16 show the carbon monoxide results. For each program, responses of each of the instruments is plotted against the standard gas values. The best fit line of the instrument results is shown on the graphs along with the theoretical line of perfect agreement. For each graph, a high degree of correlation was obtained with the linear regression.

As can be seen from the graphs, there was very good agreement between the instrument readings and the standard gases. The one instrument in Denver did show some deviation in measuring hydrocarbons. This instrument uses a flame ionization detector rather than a non-dispersive infrared detector. Also, the Portland program was consistently low in measuring carbon monoxide. The consistency of the results seems to indicate a systematic error such as low calibration gas rather than operator or instrument error.

The audit results were also subjected to analysis of variance, a statistical technique used to determine if significant differences exist between the mean values of various groupings. The instrument responses were analyzed to determine if differences exist in the results between programs, between I/M station sites, or between makes of analyzers. A separate analysis was performed on each standard gas blend for both hydrocarbons and carbon monoxide. Included are a total of 8 programs, 24 sites, and 4 makes of analyzers (Sun Electric, Beckman, Autosense and Horiba).

The variance ratio, F, is the ratio of the mean square between groups divided by the mean square within groups. F is used to test the null hypothesis that the population means are the same in all groups. F is around 1 when the hypothesis holds, and becomes large when there is a significant difference in the group means. A table of F values for various degrees of freedom is used to determine if a significant difference exists in the group means with a 95% level of confidence.[1] This analysis indicates whether or not a significant difference in the group means exists, but does not indicate which group is the source of the difference.

The results of the analysis are summarized in Table 6.2 for hydrocarbons and Table 6.3 for carbon monoxide. Tables 6.4 through 6.6 show the actual analysis for hydrocarbons between programs, sites, and analyzers. Tables 6.7 through 6.9 show the analysis between programs, sites and analyzers for carbon monoxide. The analyzers are grouped by make only, without differentiating between different models.

Variations of the hydrocarbon measurements showing significant differences were also calculated without the results from Denver, since their program used a flame ionization detector and showed the most deviation from the

[1] Sedecor and Cochran. Statistical Methods. Sixth Edition. Iowa State University Press, Ames, Iowa (1967)

TABLE 6.2

SUMMARY OF ANALYSIS OF VARIANCE FOR HYDROCARBON RESULTS

Variation:	Degree of Freedom	Variance Ratio, F Blend Number 1	2	3	4	5	Critical F (5%)
1. Between Programs	$7^1, 50^2$	1.45	1.82	1.58	5.51*	17.1*	2.20
2. Between Programs (Without Denver)	$6^1, 50^2$				3.71*	4.97*	2.29
3. Between Sites	$23^3, 34^4$	1.07	1.24	3.55*	2.73*	7.82*	1.85
4. Between Sites (Without Denver)	$22^3, 34^4$			3.43*	2.03*	3.03*	1.86
5. Between Analyzers	$3^5, 54^6$	1.37	1.59	1.31	2.68	7.86*	2.78
6. Between Analyzers (Without Denver)	$3^5, 53^6$				1.12	1.69	2.78

* F values exceeding the critical value.
Indicates a significant difference in the mean values of these groups with a 95% confidence level.

1 - Degrees of Freedom = No. of Programs - 1.
2 - Degrees of Freedom = No. of Instruments - No. of Programs.
3 - Degrees of Freedom = No. of Sites - 1.
4 - Degrees of Freedom = No. of Instruments - No. of Sites.
5 - Degrees of Freedom = No. of Analyzer Types - 1
6 - Degrees of Freedom = No. of Instruments - No. of Analyzer Types.

TABLE 6.3

SUMMARY OF ANALYSIS OF VARIANCE FOR CARBON MONOXIDE RESULTS

Variation:	Degree of Freedom	Variance Ratio, F Blend Number 1	2	3	4	5	Critical, F (5%)
1. Between Programs	7, 50	0.61	5.40*	4.16*	13.09*	14.15*	2.20
2. Between Programs (Without Portland)	6, 35	3.53*	1.55	1.42	1.47	1.99	2.37
3. Between Sites	23, 34	0.69	3.69*	2.89*	7.63*	9.34*	1.85
4. Between Sites (Without Portland)	17, 24	545*	2.22*	1.54	2.35*	2.93*	2.07
5. Between Analyzers	3, 54	0.25	2.24	3.82*	2.44	2.06	2.78
6. Between Analyzers (Without Portland)	3, 38	0.42	0.68	1.95	0.43	0.27	2.85

*F values exceeding critical value.
Indicates a significant difference in the mean values of these groups with a 95% confidence level.

TABLE 6.4

ANALYSIS OF VARIANCE

ANALYSIS OF PROGRAM VARIATION IN MEASURING HYDROCARBONS

BLEND	SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	VARIANCE RATIO, F	CRITICAL F, 5%
1	Between Programs	7	3856	551	1.45	2.20
	Within Programs	50	18980	380		
2	Between Programs	7	23476	3354	1.82	2.20
	Within Programs	50	91950	1839		
3	Between Programs	7	40770	5824	1.58	2.20
	Within Programs	50	184086	3682		
4	Between Programs	7	560357	80051	5.51	2.20
	Within Programs	50	726787	14536		
5	Between Programs	7	3263229	466176	17.1	2.20
	Within Programs	50	1359450	27189		

ANALYSIS OF PROGRAM VARIATION IN MEASURING HYDROCARBONS

(EXCLUDING DENVER PROGRAM)

BLEND	SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	VARIANCE RATIO, F	CRITICAL F, 5%
4	Between Programs	6	323527	53921	3.71	2.29
	Within Programs	50	727002	14540		
5	Between Programs	6	810468	135078	4.97	2.29
	Within Programs	50	1359964	27199		

TABLE 6.5

ANALYSIS OF VARIANCE

ANALYSIS OF SITE VARIATION IN MEASURING HYDROCARBONS

BLEND	SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	VARIANCE RATIO, F	CRITICAL F, 5%
1	Between Sites	23	9590	417	1.07	1.85
	Within Sites	34	13246	390		
2	Between Sites	23	52736	2293	1.24	1.85
	Within Sites	34	62690	1844		
3	Between Sites	23	158815	6905	3.55	1.85
	Within Sites	34	66042	1942		
4	Between Sites	23	835344	36319	2.73	1.85
	Within Sites	34	451800	13288		
5	Between Sites	23	3878315	168622	7.82	1.85
	Within Sites	34	733069	21561		

ANALYSIS OF SITE VARIATION IN MEASURING HYDROCARBONS

(EXCLUDING DENVER PROGRAM)

BLEND	SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	VARIANCE RATIO, F	CRITICAL F, 5%
3	Between Sites	22	146752	6671	3.43	1.86
	Within Sites	34	66042	1942		
4	Between Sites	22	593244	26966	2.03	1.86
	Within Sites	34	451800	13288		
5	Between Sites	22	1437363	65335	3.03	1.86
	Within Sites	34	733069	21561		

TABLE 6.6

ANALYSIS OF VARIANCE

ANALYSIS OF ANALYZER VARIATION IN MEASURING HYDROCARBONS

BLEND	SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	VARIANCE RATIO, F	CRITICAL F, 5%
1	Between Analyzers	3	1620	540	1.37	2.78
	Within Analyzers	54	21217	393		
2	Between Analyzers	3	9370	3123	1.59	2.78
	Within Analyzers	54	106056	1964		
3	Between Analyzers	3	15222	5074	1.31	2.78
	Within Analyzers	54	209634	3882		
4	Between Analyzers	3	166659	55553	2.68	2.78
	Within Analyzers	54	1120485	20750		
5	Between Analyzers	3	1401426	467142	7.86	2.78
	Within Analyzers	54	3209959	59444		

ANALYSIS OF ANALYZER VARIATION IN MEASURING HYDROCARBONS

(EXCLUDING DENVER PROGRAM)

BLEND	SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	VARIANCE RATIO, F	CRITICAL F, 5%
4	Between Analyzers	3	62373	20791	1.12	1.78
	Within Analyzers	53	982672	18541		
5	Between Analyzers	3	189785	63262	1.69	2.78
	Within Analyzers	53	1980647	37371		

TABLE 6.7

ANALYSIS OF VARIANCE

ANALYSIS OF PROGRAM VARIATION IN MEASURING CARBON MONOXIDE

BLEND	SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	VARIANCE RATIO, F	CRITICAL F, 5%
1	Between Programs	7	.0209	.00298	0.61	2.20
	Within Programs	50	.243	.00486		
2	Between Programs	7	.144	.0206	5.40	2.20
	Within Programs	50	.190	.00381		
3	Between Programs	7	.490	.0700	4.16	2.20
	Within Programs	50	.842	.0168		
4	Between Programs	7	6.23	.890	13.09	2.20
	Within Programs	50	3.40	.0680		
5	Between Programs	7	24.60	3.51	14.15	2.20
	Within Programs	50	12.42	.248		

ANALYSIS OF PROGRAM VARIATION IN MEASURING CARBON MONOXIDE
(EXCLUDING PORTLAND PROGRAM)

BLEND	SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	VARIANCE RATIO, F	CRITICAL F, 5%
1	Between Programs	6	.00730	.00122	3.53	2.37
	Within Programs	35	.0121	.000345		
2	Between Programs	6	.0373	.00621	1.55	2.37
	Within Programs	35	.141	.00402		
3	Between Programs	6	.142	.0237	1.42	2.37
	Within Programs	35	.583	.0167		
4	Between Programs	6	.760	.127	1.47	2.37
	Within Programs	35	3.02	.086		
5	Between Programs	6	3.50	.584	1.99	2.37
	Within Programs	35	10.30	.294		

TABLE 6.8

ANALYSIS OF VARIANCE

ANALYSIS OF SITE VARIATION IN MEASURING CARBON MONOXIDE

BLEND	SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	VARIANCE RATIO, F	CRITICAL F, 5%
1	Between Sites	23	.0842	.00366	.69	1.85
	Within Sites	34	.180	.00529		
2	Between Sites	23	.239	.0104	3.69	1.85
	Within Sites	34	.0957	.00281		
3	Between Sites	23	.881	.0383	2.89	1.85
	Within Sites	34	.451	.0133		
4	Between Sites	23	8.07	.351	7.63	1.85
	Within Sites	34	1.56	.0460		
5	Between Sites	23	31.96	1.39	9.34	1.85
	Within Sites	34	5.06	.149		

ANALYSIS OF SITE VARIATION IN MEASURING CARBON MONOXIDE
(EXCLUDING PORTLAND SITES)

BLEND	SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	VARIANCE RATIO, F	CRITICAL F, 5%
1	Between Sites	17	.0193	.00114	545	2.07
	Within Sites	24	.00005	.000002		
2	Between Sites	17	.109	.00640	2.22	2.07
	Within Sites	24	.0692	.00288		
3	Between Sites	17	.379	.0223	1.54	2.07
	Within Sites	24	.346	.0144		
4	Between Sites	17	2.36	.139	2.35	2.07
	Within Sites	24	1.42	.0591		
5	Between Sites	17	9.31	.548	2.93	2.07
	Within Sites	24	4.48	.187		

TABLE 6.9

ANALYSIS OF VARIANCE

ANALYSIS OF ANALYZER VARIATION IN MEASURING CARBON MONOXIDE

BLEND	SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	VARIANCE RATIO, F	CRITICAL F, 5%
1	Between Analyzers	3	.00361	.00120	.249	2.78
	Within Analyzers	54	.260	.00482		
2	Between Analyzers	3	.0370	.0123	2.24	2.78
	Within Analyzers	54	.298	.00551		
3	Between Analyzers	3	.233	.0778	3.82	2.78
	Within Analyzers	54	1.10	.0204		
4	Between Analyzers	3	1.15	.384	2.44	2.78
	Within Analyzers	54	8.48	.157		
5	Between Analyzers	3	3.81	1.27	2.06	2.78
	Within Analyzers	54	33.2	.615		

ANALYSIS OF ANALYZER VARIATION IN MEASURING CARBON MONOXIDE
(EXCLUDING PORTLAND ANALYZERS)

BLEND	SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	VARIANCE RATIO, F	CRITICAL F, 5%
1	Between Analyzers	3	.00062	.00021	.419	2.85
	Within Analyzers	38	.0187	.00049		
2	Between Analyzers	3	.00905	.00302	.679	2.85
	Within Analyzers	38	.169	.00444		
3	Between Analyzers	3	.0966	.0322	1.95	2.85
	Within Analyzers	38	.629	.0165		
4	Between Analyzers	3	.124	.0412	.428	2.85
	Within Analyzers	38	3.66	.0962		
5	Between Analyzers	8	.289	.0963	.271	2.85
	Within Analyzers	38	13.5	.355		

standard gases. The analysis shows differences between the programs for gas blends 4 and 5. The differences are reduced, but still significant, when calculated excluding the Denver results. The analysis also shows significant differences between the sites for gas blends 3, 4 and 5, both with and without the Denver results. However, the analysis of between analyzer variations did not show significant differences except for blend 5 (with the Denver results).

The analysis of carbon monoxide in general, showed less variation than the hydrocarbon measurements. This analysis was calculated with and without the Portland results since their stations were consistently low in measuring carbon monoxide. Excluding the Portland results, the analysis did not show significant differences between the programs or the analyzers. There was, however, significant differences between the sites in analyzing several of the gas blends. The zero gas also showed some variation, but this analysis is specialized since the true value is zero.

SET #2587-01-0179

APPENDIX A

SUMMARY OF ANALYSIS OF GAS BLENDS BY SCOTT ENVIRONMENTAL TECHNOLOGY, INC.

AND

ANALYSIS OF LOW PRESSURE CYLINDERS TRANSFILLED FROM MASTER CYLINDERS

SET #2587-01-0179

APPENDIX A

SUMMARY OF ANALYSIS OF GAS BLENDS BY SCOTT ENVIRONMENTAL TECHNOLOGY, INC.

ANALYSIS OF MASTER BLENDS

	Scott Gravimetric Blend[1]		Scott Analysis[2]		Scott Reanalysis[3]	
Blend	HC	CO	HC	CO	HC	CO
1	0	0	0	0	0	0
2	388	.903	385	.906	387	.903
3	821	2.13	820	2.12	823	2.13
4	1960	4.84	1945	4.81	1968	4.84
5	3840	9.56	3880	9.63	3830	9.56

HC = HYDROCARBONS, ppm AS PROPANE

CO = CARBON MONOXIDE, PERCENT BY VOLUME

Notes:
1. Gases blended gravimetrically using weights traceable to the National Bureau of Standards.
2. Scott analysis on 12-7-77 against primary standards.
3. Scott reanalysis on 4-15-78 against primary standards.

ANALYSIS OF LOW PRESSURE CYLINDERS TRANSFILLED FROM MASTER CYLINDERS

HYDROCARBONS, ppm AS PROPANE[3]

Cylinder Letter	Blend 2		Blend 3		Blend 4		Blend 5	
	Analysis[1]	Reanalysis[2]	Analysis[1]	Reanalysis[2]	Analysis[1]	Reanalysis[2]	Analysis[1]	Reanalysis[2]
A	384	386	819	820	1943	1960	3882	3798
B	385	386	819	820	1948	1960	3884	3806
G	383	387	820	821	1942	1962	3878	3810
H	384	387	821	820	1940	1960	3884	3802
I	383	387	821	823	1940	1962	3882	3806
K	384	386	819	821	1940	1960	3870	3806
L	385	386	819	821	1944	1956	3880	3806
M	385	387	822	821	1941	1958	3880	3806
N	384	386	821	820	1948	1958	3886	3806
R	384	386	824	820	1946	1958	3874	3810
S	383	386	822	820	1942	1956	3870	3806

Notes:

1. Scott analysis on 12-7-77 against primary standards.
2. Scott reanalysis on 4-15-78 against primary standards.
3. Only hydrocarbons analyzed since carbon monoxide concentration is constant relative to hydrocarbon concentration. All Blend 1 cylinders verified less than 1 ppm hydrocarbons and 1 ppm carbon monoxide.

APPENDIX B

SUMMARY OF AUDIT RESULTS INCLUDING DIFFERENCES BETWEEN INSTRUMENT READINGS AND STANDARD GASES

SUMMARY OF RESULTS OF AUDIT OF
CHICAGO DEPARTMENT OF ENVIRONMENTAL CONTROL
INSPECTION STATION
31ST STREET AND LAKESHORE DRIVE
CHICAGO, ILLINOIS

LANE NO. B

PROPANE/HEXANE FACTOR: .518

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	0	0	0	0.08	+0.08	----
2	201	201	0	0	0.76	-0.14	-15.5
3	425	432	+ 7	+1.6	1.68	-0.45	-21.1
4	1015	1027	+12	+1.2	3.61	-1.23	-25.4
5	1989	1949	-40	-2.0	7.00	-2.56	-26.8

LANE NO.

PROPANE/HEXANE FACTOR:

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1							
2							
3							
4							
5							

LANE NO.

PROPANE/HEXANE FACTOR:

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1							
2							
3							
4							
5							

SUMMARY OF RESULTS OF AUDIT OF
CHICAGO DEPARTMENT OF ENVIRONMENTAL CONTROL
INSPECTION STATION
5401 NORTH ELSTON AVENUE
CHICAGO, ILLINOIS

LANE NO. A

PROPANE/HEXANE FACTOR: .510

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	40	+40	-	0.0	0.0	0.0
2	198	256	+58	+29.3	1.0	+0.1	+11.1
3	419	474	+55	+13.1	2.1	0.0	0.0
4	1000	1074	+74	+ 7.4	4.7	-0.1	- 2.1
5	1958	1976	+18	+ 0.9	9.2	-0.4	- 4.2

LANE NO. B

PROPANE/HEXANE FACTOR: .519

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	-1.5	-1.5	---	0.0	0.0	0.0
2	201	246	+45	+22.4	0.9	0.0	0.0
3	426	522	+96	+22.5	2.2	+0.1	+4.7
4	1017	1232	+215	+21.1	4.8	0.0	0.0
5	1993	2254	+261	+13.1	9.7	+0.1	+1.0

LANE NO. _____

PROPANE/HEXANE FACTOR: _____

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1							
2							
3							
4							
5							

CHIC

MARY OF RESULTS OF AUDIT OF
EPARTMENT OF ENVIRONMENTAL PROTECTION
INSPECTION STATION
7150 WEST MEDILL AVENUE
CHICAGO, ILLINOIS

LANE NO. 1A PROPANE/HEXANE FACTOR: .516

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	0	0	0	0.0	0.0	0.0
2	200	218	+18	+9.0	0.9	0.0	0.0
3	424	462	+38	+9.0	1.9	-0.2	- 9.4
4	1011	1084	+73	+7.2	4.3	-0.5	-10.3
5	1981	2000+	---	----	8.8	-0.8	- 8.4

LANE NO. 2B PROPANE/HEXANE FACTOR: .510

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	-2	- 2	---	0.0	0.0	0.0
2	198	212	+14	+7.1	1.0	+0.1	+11.1
3	419	456	+37	+8.8	2.3	+0.2	+ 9.4
4	1000	1073	+73	+7.3	5.4	+0.6	+12.4
5	1958	2000+	---	----	10.0	+0.4	+ 4.2

LANE NO. _____ PROPANE/HEXANE FACTOR: _____

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1							
2							
3							
4							
5							

SET #2587-01-0179

SUMMARY OF RESULTS OF AUDIT OF
CHICAGO DEPARTMENT OF ENVIRONMENTAL CONTROL
INSPECTION STATION
4046 WEST WASHINGTON STREET
CHICAGO, ILLINOIS

LANE NO. A

PROPANE/HEXANE FACTOR: .518

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	20	+ 20	---	-0.09	-.09	-----
2	201	197	- 4	- 2.0	0.96	+.06	+6.6
3	425	394	- 31	- 7.3	2.10	-.03	-1.4
4	1015	912	-103	-10.1	4.78	-.06	-1.2
5	1989	1646	-343	-17.2	9.14	-.42	-4.4

LANE NO. B

PROPANE/HEXANE FACTOR: .506

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	0	0	0	-0.08	-.08	-----
2	196	208	+ 12	+ 6.1	0.89	-.01	-1.1
3	415	443	+ 28	+ 6.7	2.15	+.02	+0.9
4	992	1041	+ 49	+ 4.9	4.69	-.15	-3.1
5	1943	1972	+ 29	+ 1.5	9.36	-.20	-2.1

LANE NO. _____

PROPANE/HEXANE FACTOR: _____

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1							
2							
3							
4							
5							

SUMMARY OF RESULTS OF AUDIT OF CINCINNATI DIVISION OF AIR POLLUTION CONTROL INSPECTION STATION CENTRAL PARKWAY, CINCINNATI, OHIO

SERIAL ~~LANE~~ NO. 001 PROPANE/HEXANE FACTOR: .526

Blend	HC (ppm Hexane) Scott Analysis	Station Reading	Difference	(%)	CO (%) Station Reading	Difference	(%)
1	0	0	0	0	0	0	0
2	204	300	+96	+47	.980	+.08	+8.9
3	432	425	- 7	-1.6	2.2	+.07	+3.3
4	1031	1000	-31	-3.0	5.0	+.16	+3.3
5	2020	1975	-45	-2.2	10.0	+.44	+4.6

SERIAL ~~LANE~~ NO. 002 PROPANE/HEXANE FACTOR: .520

Blend	HC (ppm Hexane) Scott Analysis	Station Reading	Difference	(%)	CO (%) Station Reading	Difference	(%)
1	0	0	0	0	0	0	0
2	202	275	+73	+36	.90	0	0
3	427	400	-27	-6.3	2.1	-.03	-1.4
4	1019	900	-119	-11.7	4.75	-.09	-1.9
5	1997	1700	-297	-14.9	9.75	+.19	+2.0

SERIAL ~~LANE~~ NO. 004 PROPANE/HEXANE FACTOR: .541

Blend	HC (ppm Hexane) Scott Analysis	Station Reading	Difference	(%)	CO (%) Station Reading	Difference	(%)
1	0	10	+10	-	0	0	0
2	210	200	-10	-4.8	.980	+.08	+8.9
3	444	420	-24	-5.4	2.2	+.07	+3.3
4	1060	1020	-40	-3.8	4.75	-.09	-1.9
5	2077	1980	-97	-4.7	9.80	+.24	+2.5

SERIAL
~~LANE~~ NO. 005

PROPANE/HEXANE FACTOR: .492

Blend	HC (ppm Hexane) Scott Analysis	Station Reading	Difference	(%)	CO (%) Station Reading	Difference	(%)
1	0	0	0	0	0	0	0
2	191	180	- 9	-4.7	1.0	+.1	+11.1
3	404	380	- 24	-5.9	2.2	+.07	+ 3.3
4	964	930	- 34	-3.5	4.6	-.24	- 5.0
5	1889	1725	-164	-8.7	9.5	-.06	- 0.6

SERIAL
~~LANE~~ NO. 006

PROPANE/HEXANE FACTOR: .544

Blend	HC (ppm Hexane) Scott Analysis	Station Reading	Difference	(%)	CO (%) Station Reading	Difference	(%)
1	0	0	0	0	0	0	0
2	211	210	- 1	-0.5	.98	+.08	+8.9
3	447	440	- 7	-1.6	2.25	+.12	+5.6
4	1066	1025	- 41	-3.8	5.0	+.16	+3.3
5	2089	1980	-109	-5.2	10.4	+.84	+8.8

SERIAL
~~LANE~~ NO. 007

PROPANE/HEXANE FACTOR: .528

Blend	HC (ppm Hexane) Scott Analysis	Station Reading	Difference	(%)	CO (%) Station Reading	Difference	(%)
1	0	0	0	0	0	0	0
2	205	210	+ 5	+2.4	.970	+.07	+7.7
3	433	430	- 3	-0.7	2.2	+.07	+3.3
4	1035	1025	-10	-1.0	4.75	-.09	-1.9
5	2028	2000	-28	-1.4	10.0	+.44	+4.6

SET #2587-01-0179

SUMMARY OF RESULTS OF AUDIT OF

CINCINNATI DIVISION OF AIR POLLUTION CONTROL
INSPECTION STATION
NORWOOD, OHIO

LANE NO. 1 PROPANE/HEXANE FACTOR: .540

Blend	HC (ppm Hexane) Scott Analysis	Station Reading	Difference	(%)	CO (%) Station Reading	Difference	(%)
1	0	0	0	0	0	0	0
2	210	210	0	0	.90	0	0
3	443	450	+ 7	+1.6	2.0	-.13	-6.1
4	1058	1025	-33	-3.1	4.5	-.34	-7.0
5	2074	2000	-74	-3.6	9.5	-.06	-0.6

LANE NO. _____ PROPANE/HEXANE FACTOR: _____

Blend	HC (ppm Hexane) Scott Analysis	Station Reading	Difference	(%)	CO (%) Station Reading	Difference	(%)
1							
2							
3							
4							
5							

LANE NO. _____ PROPANE/HEXANE FACTOR: _____

Blend	HC (ppm Hexane) Scott Analysis	Station Reading	Difference	(%)	CO (%) Station Reading	Difference	(%)
1							
2							
3							
4							
5							

SUMMARY OF RESULTS OF AUDIT AT COLORADO DEPT. OF
HEALTH I/M STATION, DENVER, COLORADO
JANUARY 10, 1978

Blend	HC ppm (Propane) Actual	Sta. Reading	Difference	(%)
1	<1	16	+16	---
2	388	438	+50	13
3	821	916.7	+96	12
4	1960	2458	+498	25
5	3840	5297.7	+1458	38

Blend	CO (%) Actual	Sta. Reading	Difference	(%)
1	<1 ppm	.01	+.01	---
2	0.903	.91	+.007	+.8
3	2.13	2.12	+.01	+.5
4	4.84	4.72	-.12	-2.5
5	9.56	10.27	+.71	+7

NEW JE

RY OF RESULTS OF AUDIT OF
RTMENT OF ENVIRONMENTAL PROTECTION
INSPECTION STATION
61 CENTRAL AVENUE
OMERVILLE, NEW JERSEY

e lane, three instruments)

SERIAL ~~LANE~~ NO. 100

PROPANE/HEXANE FACTOR: 0.52

Blend	HC (ppm Hexane) Scott Analysis	Station Reading	Difference	(%)	CO (%) Station Reading	Difference	(%)
1	0	0	0	0	0.0	0	0
2	202	200	- 2	-1.0	1.0	+0.10	+11.1
3	427	400	-27	-6.3	2.0	-0.13	- 6.1
4	1019	1040	+21	+2.1	5.0	+0.16	+ 3.3
5	1997	2140*	+43	+2.2	9.2	-0.36	- 3.8

SERIAL ~~LANE~~ NO. 073

PROPANE/HEXANE FACTOR: 0.55

Blend	HC (ppm Hexane) Scott Analysis	Station Reading	Difference	(%)	CO (%) Station Reading	Difference	(%)
1	0	30	+30	----	0.0	0	0
2	213	260	+47	+22.1	1.0	+0.10	+11.1
3	452	360	-92	-20.4	2.3	+0.17	+ 8.0
4	1078	1110	+32	+ 3.0	5.2	+0.36	+ 7.4
5	2112	2000*+	---	-----	10.2	+0.64	+ 6.7

SERIAL ~~LANE~~ NO. 091

PROPANE/HEXANE FACTOR: 0.52

Blend	HC (ppm Hexane) Scott Analysis	Station Reading	Difference	(%)	CO (%) Station Reading	Difference	(%)
1	0	0	0	----	0.0	0	0
2	202	190	-12	-5.9	0.9	0	0
3	427	420	- 7	-1.6	2.2	-0.07	-3.2
4	1019	990	-29	-2.8	5.0	+0.16	+3.2
5	1997	1960	-37	-1.9	9.7	+0.14	+1.4

* Off Scale

SUMMARY OF RESULTS OF AUDIT OF
NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
INSPECTION STATION
RIDGEDALE AVENUE AND WASHINGTON PLACE
MORRISTOWN, NEW JERSEY

(Two lanes, three instruments)

LANE NO. 045 PROPANE/HEXANE FACTOR: 0.52

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	0	0	0	0.0	0	0
2	202	200	- 2	-1.0	0.9	0.00	0.0
3	427	400	-27	-6.8	2.1	-0.03	-1.4
4	1019	1060	+41	+3.9	5.3	+0.46	+9.5
5	1997	2040*	+43	+2.1	9.7	+0.14	+1.5

LANE NO. 124 PROPANE/HEXANE FACTOR: 0.53

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	0	0	0	0.0	0	0
2	206	180	-26	-12.6	0.8	-0.10	-11.1
3	435	400	-35	- 8.0	2.0	-0.13	- 6.1
4	1039	1000	-39	- 3.8	4.8	-0.04	- 0.8
5	2035	2060*	+25	+ 1.2	10.0	+0.44	+ 4.6

LANE NO. 051 PROPANE/HEXANE FACTOR: 0.53

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	0	0	0	0.0	0	0
2	206	220	+14	+6.8	1.0	+0.10	+11.1
3	435	430	- 5	-1.1	2.2	+0.07	+ 3.3
4	1039	1060	+21	+2.0	5.2	+0.36	+ 7.4
5	2035	2060*	+25	+1.2	10.2	+0.64	+ 6.7

* Off Scale

SUMMARY OF RESULTS OF AUDIT OF
NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
INSPECTION STATION
156 CHESTNUT STREET
RIDGEWOOD, NEW JERSEY

(One lane, two instruments)

SERIAL
~~LANE~~ NO. 055 PROPANE/HEXANE FACTOR: 0.52

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	0	0	0	0.0	0	0
2	202	200	- 2	-1.0	0.9	0.00	0
3	427	420	- 7	-1.6	2.0	-0.13	-6.1
4	1019	1030	+11	+1.1	4.7	-0.14	-2.9
5	1997	2020	+23	+1.2	9.6	+0.04	+0.4

SERIAL
~~LANE~~ NO. 063 PROPANE/HEXANE FACTOR: 0.50

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	0	0	0	0.0	0	0
2	194	200	+ 6	+3.1	0.8	-0.10	-11.1
3	410	400	-10	-2.4	2.2	+0.07	+ 3.3
4	980	1040	+60	+6.1	5.0	+0.16	+ 3.3
5	1920	2000	+80	+4.2	9.9	+0.34	+ 3.6

SERIAL
~~LANE~~ NO. _____ PROPANE/HEXANE FACTOR: _____

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1							
2							
3							
4							
5							

SUMMARY OF RESULTS OF AUDIT OF
NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
INSPECTION STATION
935 LAKEWOOD ROAD
TOM'S RIVER, NEW JERSEY

(One lane, three instruments)

SERIAL ~~LANE~~ NO. 101

PROPANE/HEXANE FACTOR: 0.52

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	0	0	0	0.0	0.00	0
2	202	160	-42	-20.8	0.8	-0.10	-11.1
3	427	370	-57	-13.3	1.9	-0.23	-10.8
4	1019	980	-39	- 3.8	4.8	-0.04	- 0.8
5	1997	1960	-37	- 1.9	9.4	-0.16	- 1.7

SERIAL ~~LANE~~ NO. 102

PROPANE/HEXANE FACTOR: 0.52

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	30	+30	----	0.0	0	0
2	202	180	-22	-10.9	0.9	0.00	0
3	427	420	- 7	- 1.6	2.1	-0.03	-1.4
4	1019	980	-39	- 3.8	4.7	-0.14	-2.9
5	1997	2000+	+ 3	+ 0.2	9.2	-0.36	-3.8

SERIAL ~~LANE~~ NO. 103

PROPANE/HEXANE FACTOR: 0.53

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	0	0	0	0.0	0	0
2	206	200	- 6	- 2.9	0.8	-0.10	-11.1
3	435	500	+ 65	+14.9	2.1	-0.03	- 1.4
4	1039	1320	+281	+27.0	4.6	-0.24	- 5.0
5	2035	2000*+	----	-----	9.5	-0.06	- 0.6

* Off Scale

Scott Environmental Technology, Inc.

SUMMARY OF RESULTS OF AUDIT OF
NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
INSPECTION STATION
U.S. HIGHWAY 9 AND SHELLBAY AVENUE
CAPE MAY, NEW JERSEY

(One lane, two instruments)

SERIAL NO. 107 PROPANE/HEXANE FACTOR: 0.52

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	0	0	0	0.0	0	0
2	202	210	+ 8	+ 4.0	0.75	-0.15	-16.6
3	427	430	+ 3	+ 0.7	1.8	-0.33	-15.5
4	1019	1125	+106	+10.4	4.5	-0.34	- 7.0
5	1997	2000+*	-----	-----	8.3	-1.26	-13.2

SERIAL NO. 106 PROPANE/HEXANE FACTOR: 0.52

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	0	0	0	0.0	0	0
2	202	250	+48	+23.8	0.9	0.00	0
3	427	460	+33	+ 7.7	2.3	+0.17	+ 8.0
4	1019	1190	+171	+16.8	5.4	+0.56	+11.6
5	1997	2000+*	----	-----	10.4*	+0.84	+ 8.8

* Off Scale

LANE NO._____ PROPANE/HEXANE FACTOR:_____

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1							
2							
3							
4							
5							

SUMMARY OF RESULTS OF AUDIT OF
NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
VEHICLE EMISSIONS TEST LABORATORY
8 HEMLOCK STREET
LATHAM, NEW YORK

LANE NO. 1 PROPANE/HEXANE FACTOR: 0.530

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	0	0	0	0	0	0
2	206	220	+14	+6.8	0.9	0.0	0
3	435	440	+ 5	+1.1	2.1	-0.03	-1.4
4	1039	1080	+41	+3.9	4.6	-0.24	-5.0
5	2035	2000+	---	----	9.3	-0.26	-2.7

LANE NO. Mobile Van PROPANE/HEXANE FACTOR: 0.541

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	20	+20	-----	0	0	0
2	210	220	+10	+4.8	0.9	0.0	0
3	444	460	+16	+3.6	2.0	-0.13	-6.1
4	1060	1060	0	0	4.5	-0.34	-7.0
5	2077	2010	-67	-3.2	9.0	-0.56	-5.9

LANE NO. _____ PROPANE/HEXANE FACTOR: _____

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1							
2							
3							
4							
5							

SUMMARY OF RESULTS OF AUDIT OF ARIZONA BUREAU OF
VEHICULAR EMISSIONS INSPECTION
STATE VEHICLE ENGINE EMISSIONS LABORATORY
600 NO. 40TH STREET, PHOENIX, AR.

LANE NO._____ PROPANE/HEXANE FACTOR: 0.52

	HC (ppm Hexane)				CO		
Blend	Scott Analysis	Station Reading	Difference	(%)	(%)	Difference	(%)
1	0	1	+1	---	0.01	+0.01	---
2	202	202	0	0	.93	+0.03	+3.2
3	427	416	-11	-2.6	2.17	+0.04	+1.9
4	1019	1005	-14	-1.4	4.85	+0.01	+0.2
5	1997	1955	-42	-2.1	9.45	-0.11	-1.2

SUMMARY OF RESULTS OF AUDIT OF ARIZONA BUREAU
OF VEHICULAR EMISSIONS INSPECTION
STATION
2450 S. 7TH STREET, PHOENIX, AR.

LANE NO. 1 PROPANE/HEXANE FACTOR: 0.590

	HC (ppm Hexane)				CO		
Blend	Scott Analysis	Station Reading	Difference	(%)	(%)	Difference	(%)
1	0	0	0	0	0.00	0	0
2	229	220	-9	-3.9	0.94	+0.04	+4.4
3	484	450	-34	-7.0	2.20	+0.07	+3.3
4	1156	1110	-46	-4.0	4.78	-0.06	-1.2
5	2266	2300	+34	+1.5	9.48	-0.08	-0.8

LANE NO. 2 PROPANE/HEXANE FACTOR: 0.598

	HC (ppm Hexane)				CO		
Blend	Scott Analysis	Station Reading	Difference	(%)	(%)	Difference	(%)
1	0	0	0	0	0.00	0	0
2	232	220	-12	-5.2	0.91	+0.01	+1.1
3	491	460	-31	-6.3	2.16	+0.03	+1.4
4	1172	1120	-52	-4.4	4.80	-0.04	-0.8
5	2296	2270	-26	-1.1	9.41	-0.15	-1.6

LANE NO. 3 PROPANE/HEXANE FACTOR: 0.604

	HC (ppm Hexane)				CO		
Blend	Scott Analysis	Station Reading	Difference	(%)	(%)	Difference	(%)
1	0	0	0	0	0.00	0	0
2	234	220	-14	-6.0	0.94	+0.04	+4.4
3	496	460	-36	-7.3	2.21	+0.08	+3.8
4	1184	1130	-54	-4.6	4.98	+0.14	+2.9
5	2319	2340	+21	+0.9	9.75	+0.19	+2.0

SUMMARY OF RESULTS OF AUDIT OF ARIZONA BUREAU OF
EMISSIONS INSPECTION STATION
1830 W. BROADWAY, MESA, ARIZONA

LANE NO. 1 PROPANE/HEXANE FACTOR: 0.566

Blend	HC (ppm Hexane) Scott Analysis	HC (ppm Hexane) Station Reading	Difference	(%)	CO (%)	Difference	(%)
1	0	0	0	0	0.00	0	0
2	220	210	-10	-4.5	0.94	+0.04	+4.4
3	465	430	-35	-7.5	2.24	+0.11	+5.2
4	1109	1070	-39	-3.5	4.99	+0.15	+3.1
5	2173	2140	-33	-1.5	9.85	+0.29	+3.0

LANE NO. 2 PROPANE/HEXANE FACTOR: 0.572

Blend	HC (ppm Hexane) Scott Analysis	HC (ppm Hexane) Station Reading	Difference	(%)	CO (%)	Difference	(%)
1	0	0	0	0	0.00	0	0
2	222	210	-12	-5.4	0.94	+0.04	+4.4
3	470	450	-20	-4.3	2.19	+0.06	+2.8
4	1121	1090	-31	-2.8	4.99	+0.15	+3.1
5	2196	2200	+4	+0.2	9.77	+0.21	+2.2

LANE NO. 3 PROPANE/HEXANE FACTOR: 0.591

Blend	HC (ppm Hexane) Scott Analysis	HC (ppm Hexane) Station Reading	Difference	(%)	CO (%)	Difference	(%)
1	0	0	0	0	0.00	0	0
2	229	220	-9	-3.9	0.92	+0.02	+2.2
3	485	460	-25	-5.2	2.21	+0.08	+3.6
4	1158	1110	-48	-4.1	4.90	+0.06	+1.2
5	2269	2260	-9	-0.4	9.55	-0.01	-0.01

SET #2587-01-0179

SUMMARY OF RESULTS OF AUDIT OF ARIZONA BUREAU
OF VEHICULAR EMISSIONS INSPECTION
STATION
8125 E. 22ND ST., TUCSON, AR.

LANE NO. 1

PROPANE/HEXANE FACTOR: 0.603

Blend	HC (ppm Hexane) Scott Analysis	HC (ppm Hexane) Station Reading	Difference	(%)	CO (%)	Difference	(%)
1	0	0	0	0	0.00	0	0
2	234	220	-14	-6.0	0.94	+0.04	+4.4
3	495	470	-25	-5.1	2.20	+0.07	+3.3
4	1182	1150	-32	-2.7	4.92	+0.08	+1.7
5	2316	2360	+44	+1.9	9.78	+0.22	+2.3

LANE NO. 2

PROPANE/HEXANE FACTOR: 0.603

Blend	HC (ppm Hexane) Scott Analysis	HC (ppm Hexane) Station Reading	Difference	(%)	CO (%)	Difference	(%)
1	0	0	0	0	0.00	0	0
2	234	220	-14	-6.0	0.93	+0.03	+3.3
3	495	480	-15	-3.0	2.15	+0.02	+0.9
4	1182	1140	-42	-3.6	4.81	-0.03	-0.6
5	2316	2350	+34	+1.5	9.41	-0.15	-1.6

LANE NO. 3

PROPANE/HEXANE FACTOR: 0.603

Blend	HC (ppm Hexane) Scott Analysis	HC (ppm Hexane) Station Reading	Difference	(%)	CO (%)	Difference	(%)
1	0	0	0	0	0.00	0	0
2	234	230	-4	-1.7	0.95	+0.05	+5.5
3	495	480	-15	-3.0	2.21	+0.08	+3.8
4	1182	1140	-42	-3.6	4.89	+0.05	+1.0
5	2316	2340	+24	+1.0	9.60	+0.04	+0.4

SUMMARY OF RESULTS OF AUDIT OF
OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY
INSPECTION STATION
11626 S.W. PACIFIC HIGHWAY
TIGARD, OREGON

(Two Lanes, Three Instruments)

SERIAL ~~LANE~~ NO. U-4100 PROPANE/HEXANE FACTOR: 0.544

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	30	+30	----	0.0	0	0
2	211	240	+29	+13.7	0.9	0.00	0
3	447	470	+23	+ 5.1	2.1	-0.03	-1.4
4	1066	1095	+29	+ 2.7	4.2	-0.64	-13.2
5	2089	2000+	---	-----	8.3	-1.26	-13.2

SERIAL ~~LANE~~ NO. L-3394 PROPANE/HEXANE FACTOR: 0.525

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	5	+ 5	-----	0.0	0	0
2	204	205	+ 1	+0.5	0.8	-0.10	-11.1
3	431	445	+14	+3.2	2.0	-0.13	- 6.1
4	1029	1045	+16	+1.6	4.3	-0.54	-11.2
5	2016	1995	-21	-1.0	8.6	-0.96	-10.0

SERIAL ~~LANE~~ NO. T-3399 PROPANE/HEXANE FACTOR: 0.540

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	10 to 15	+10 to +15	-----	0.0	0	0
2	210	220	+10	+4.8	0.9	0.00	0
3	443	450	+ 7	+1.6	2.1	-0.03	-1.4
4	1058	1070	+12	+1.1	4.3	-0.54	-11.2
5	2074	2000+	---	----	8.5	-1.06	-11.1

SUMMARY OF RESULTS OF AUDIT OF
OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY
INSPECTION STATION
8920 S.E. POWELL BLVD., LANE NO. 1
PORTLAND, OREGON

(Two Lanes, Four Instruments)

LANE NO. 1 , Serial No. H-2836 PROPANE/HEXANE FACTOR: 0.544

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	5	+ 5	----	0.0	0	0
2	211	195	-16	-7.6	0.75	-0.15	-16.6
3	447	420	-27	-6.0	1.8	-0.33	-15.5
4	1066	980	-86	-8.1	3.95	-0.89	-18.4
5	2089	1910	-179	-8.6	8.0	-1.56	-16.3

LANE NO. 1, Serial No. S-3383 PROPANE/HEXANE FACTOR: 0.537

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	40	+40	----	0.05	+0.05	-----
2	208	235	+27	+13.0	0.85	-0.05	- 5.5
3	441	455	+14	+ 3.2	2.1	-0.03	- 1.4
4	1053	1045	- 8	- 0.8	4.05	-0.79	-16.3
5	2062	1900	-162	- 7.9	7.85	-1.71	-17.9

LANE NO. _____ PROPANE/HEXANE FACTOR: _____

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1							
2							
3							
4							
5							

SET #2587-01-0179

SUMMARY OF RESULTS OF AUDIT OF
OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY
INSPECTION STATION
8920 S.E. POWELL BLVD., LANE NO. 2
PORTLAND, OREGON

(Two Lanes, Four Instruments)

LANE NO. 2, Serial No. Z-3385 PROPANE/HEXANE FACTOR: 0.535

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	20	+20	----	0.0	0	0
2	208	200	- 8	-3.8	0.7	-0.20	-22.1
3	439	400	-39	-8.9	1.70	-0.43	-20.2
4	1049	1045	- 4	-0.4	4.05	-0.79	-16.3
5	2054	1865	-189	-9.2	7.8	-1.76	-18.4

LANE NO. 2, Serial No. I-2837 PROPANE/HEXANE FACTOR: 0.531

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	20	+20	----	0.5	+0.5	----
2	206	220	+14	+6.8	0.85	-0.05	- 5.5
3	436	440	+ 4	+0.9	1.8	-0.33	-15.5
4	1041	1055	+14	+1.3	4.15	-0.69	-14.3
5	2039	1895	-144	-7.1	8.40	-1.16	-12.1

LANE NO. _____ PROPANE/HEXANE FACTOR: _____

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1							
2							
3							
4							
5							

SET #2587-01-0179

SUMMARY OF RESULTS OF AUDIT OF
OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY
INSPECTION STATION
4621 N.W. ST. HELENS ROAD
PORTLAND, OREGON

(Two Lanes, Three Instruments - One Not Operational)

SERIAL ~~LANE~~ NO. A-2829 PROPANE/HEXANE FACTOR: 0.535

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	5	+ 5	---	0.0	0	0
2	208	210	+ 2	+1.0	0.85	-0.05	- 5.5
3	439	440	+ 1	+0.2	2.0	-0.13	- 6.1
4	1049	1045	+ 4	+0.4	4.25	-0.59	-12.2
5	2054	1995	-59	-2.9	8.35	-1.21	-12.7

SERIAL ~~LANE~~ NO. 0-3393 PROPANE/HEXANE FACTOR: 0.535

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	5	+ 5	---	0.05	+0.05	----
2	208	215	+ 7	+3.4	0.85	-0.05	- 5.5
3	439	445	+ 6	+1.4	2.05	-0.08	- 3.8
4	1049	1040	- 9	-0.9	4.30	-0.54	-11.2
5	2054	2000+	---	----	8.65	-0.91	- 9.5

LANE NO. _____ PROPANE/HEXANE FACTOR: _____

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1							
2							
3							
4							
5							

SUMMARY OF RESULTS OF AUDIT OF
OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY
INSPECTION STATION
18345 S.E. STARK STREET
PORTLAND, OREGON

(Two Lanes, Three Instruments)

SERIAL ~~LANE~~ NO. AA-3390 PROPANE/HEXANE FACTOR: 0.534

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	5	+ 5	----	0.0	0	0
2	207	185	-22	-10.6	0.75	-0.15	-16.6
3	438	400	-38	- 8.7	1.85	-0.28	-13.1
4	1047	915	-132	-12.6	3.85	-0.99	-20.5
5	2051	1840	-211	-10.3	8.10	-1.46	-15.3

SERIAL ~~LANE~~ NO. M-3389 PROPANE/HEXANE FACTOR: 0.523

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	10	+10	----	0.00	0	0
2	203	205	+ 2	+1.0	0.80	-0.10	-11.1
3	429	425	- 4	-0.9	1.95	-0.18	- 8.5
4	1025	1010	-15	-1.5	4.15	-0.69	-14.3
5	2008	1875	-133	-6.6	8.10	-1.46	-15.3

SERIAL ~~LANE~~ NO. N-3388 PROPANE/HEXANE FACTOR: 0.531

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	15	+ 15	----	0.05	+0.05	----
2	206	200	- 6	- 2.9	0.80	-0.10	-11.1
3	436	405	- 31	- 7.1	1.85	-0.28	-13.1
4	1041	960	- 81	- 7.8	3.90	-0.94	-19.4
5	2039	1800	-239	-11.7	7.50	-2.06	-21.5

SET #2587-01-0179

SUMMARY OF RESULTS OF AUDIT OF
OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY
MOBILE INSPECTION STATION
185TH STREET AND SUNSET HIGHWAY

(One Lane, Two Instruments)

SERIAL ~~LANE~~ NO. V-3386 PROPANE/HEXANE FACTOR: 0.525

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	0	0	0	0.0	0	0
2	204	210	+ 6	+2.9	0.85	-0.05	-5.5
3	431	440	+ 9	+2.1	2.1	-0.03	-1.4
4	1029	1055	+26	+2.5	4.4	-0.44	-9.1
5	2016	2000	-16	-0.8	8.80	-0.76	-7.9

SERIAL ~~LANE~~ NO. W-3387 PROPANE/HEXANE FACTOR: 0.537

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	15	+15	---	0.00	0	0
2	208	210	+ 2	+1.0	0.90	0	0
3	441	425	-16	-3.6	2.1	-0.03	-1.4
4	1053	990	-63	-6.0	4.1	-0.74	-15.3
5	2062	2000+	---	----	8.6	-0.96	-10.0

LANE NO. _____ PROPANE/HEXANE FACTOR: _____

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1							
2							
3							
4							
5							

Scott Environmental Technology Inc.

SUMMARY OF RESULTS OF AUDIT OF
OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY
MOBILE INSPECTION STATION
LLOYD CENTER, N.E. 15TH STREET AND MULTNOMAH STREET

(Two Lanes, Three Instruments - One Not Operational)

SERIAL ~~LANE~~ NO. D-2832 PROPANE/HEXANE FACTOR: 0.535

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	0	0	0	0.0	0	0
2	208	200	- 8	-3.8	0.8	-0.10	-11.1
3	439	415	-24	-5.5	1.9	-0.23	-10.8
4	1049	980	-69	-6.6	4.0	-0.84	-17.4
5	2054	1860	-94	-4.6	7.8	-1.76	-18.4

SERIAL ~~LANE~~ NO. C-2831 PROPANE/HEXANE FACTOR: 0.530

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1	0	0	0	0	0.0	0	0
2	206	210	+ 4	+1.9	0.8	-0.10	-11.1
3	435	420	-15	-3.4	1.9	-0.23	-10.8
4	1039	1030	- 9	-0.9	4.2	-0.64	-13.2
5	2035	1870	-65	-3.2	7.9	-1.66	-17.4

LANE NO. _____ PROPANE/HEXANE FACTOR: _____

	HC (ppm Hexane)				CO (%)		
Blend	Scott Analysis	Station Reading	Difference	(%)	Station Reading	Difference	(%)
1							
2							
3							
4							
5							

SUMMARY OF RESULTS OF AUDIT AT CAL. B.A.R. I/M STATION
RIVERSIDE, CALIFORNIA JANUARY 5, 1978

Actual Concentration

Blend	HC (ppm Hexane)	CO (%)
1	<1	<1 ppm
2	202	0.903
3	427	2.13
4	1019	4.84
5	1997	9.56

Lane No. 1 Readings

Blend	HC (ppm Hexane)	Difference	(%)	CO (%)	Difference	(%)
1	0	0	0	0.00	0	0
2	208	+6	3.0	0.96	+0.06	6.3
3	429	+2	0.5	2.25	+0.12	+5.6
4	1044	+25	2.5	4.97	+0.13	+2.7
5	2037	+40	2.0	9.58	+0.02	+0.2

Lane No. 2 Readings

Blend	HC (ppm Hexane)	Difference	(%)	CO (%)	Difference	(%)
1	1	+1	---	0.00	0	0
2	212	+10	+5.0	0.97	+0.07	+7.4
3	432	+5	+1.2	2.25	+0.12	+5.6
4	1042	+23	+2.3	4.97	+0.13	+2.7
5	2037	+40	+2.0	9.55	-0.01	-0.1